Journal of the Society of Arts.

FRIDAY, DECEMBER 14, 1855.

FOURTH ORDINARY MEETING.

WEDNESDAY DECEMBER 12, 1855.

The Fourth Ordinary Meeting of the One Hundred and Second Session was held on Wednesday, the 12th inst., Chandos Wren Hoskyns, Esq., in the chair.

On the table were exhibited some specimens of Indian Fibres from Mr. Watson, and two blocks of Preserved Coal from Mr. Wood, particulars of which will be given in the succeeding numbers of the *Journal*.

The following candidates were balloted for and duly elected:—

Aston, Theo.
Coulson, William
Tracy, John

The paper read was:—

ON THE PROGRESS AND RESULTS OF THE UNDER-DRAINAGE OF LAND IN GREAT BRITAIN.

By J. Bailey Denton.

In selecting the subject of drainage as a topic for consideration, at a moment when war and its consequences upon the corn producing countries of Europe have brought the price of wheat to 11s. 6d. per bushel, and the price of bread to 10d. the loaf, the Council of this Society have been doubtless influenced by a desire to extend the knowledge we possess of an art which has been rightly esteemed the foundation of agricultural improvement, and the most simple and certain means by which the produce of the soil may be increased.

If we consider the deprivations which seem to be multiplying upon us, we shall be led to appreciate more sensibly the importance of the present inquiry, and we shall be struck with the fact, well known, but too little reflected upon, that in proportion as extremely high prices move the community at large to desire that the capabilities of our native soil should be more fully developed, in order to increase its produce of food, so do many owners of that soil abate their zeal in pursuit of improvements necessarily admitted, though but partially performed, during the more pressing difficulties of extremely low prices.

If this should sound like mere assertion, the evidence afforded by the expenditure in drainage, under the Government loan, will leave no doubt on the point, for in 1852, when wheat was 40s. 9d. the quarter, the expenditure was £412,269 15s. 6d. It became in 1853, when wheat rose to 53s. 3d. per quarter, £334,115 13s. 3d.; and declined still further in 1854, when the price was 72s. 5d. per quarter, to £316,220 7s. 4d., or about £100,000 less than in 1852.

This fact, in its reference to the particular subject of drainage, is the more to be lamented, because the operation may be considered essentially to rank among the obligations of the owner and not the occupier of the land, and it is so necessary to found the present discussion upon a right understanding of this important point, that I must be pardoned for dwelling upon it.

It is hardly 12 months ago since I had an opportunity of introducing this subject to the attention of the London Central Farmers' Club, the members of which are for the most part tenant farmers; and it was then suggested to me, that however convincing the evidence might be in proof of the profitable results from systematic drainage, and however interesting in themselves the details of the necessary operations, it was so manifest that drainage, to be satisfactory, must be done effectually and permanently, and must therefore involve such a much larger outlay than a tenant farmer could be expected to make, that my statements should be rather addressed to the owners than to the occupiers of land.

The whole tenor of the discussion on that occasion went to show, that considerations of *expediency* were paramount with those whose interest in the soil was limited by the nature of their tenancy, while it was contended that *principle* should rule with those whose interest in the soil was permanent and secure.

This practical view and treatment of the subject could hardly be reprehended, when it is remembered that whereas the average amount of capital employed by occupiers in the cultivation of the inferior wet lands of Great Britain may be estimated not to exceed £6 per acre, the cost of permanently draining these lands would amount to about £5 per acre, so that if the tenants who farm them were to apply their capital at once to this fundamental work, they would be left with only £1 per acre to provide for all the other expenditure on their farms.

If this is so, the proposition becomes reduced to a practical absurdity, for the average amount of capital actually employed in the cultivation of the inferior heavy lands, is known to be insufficient to secure even creditable or profitable treatment, irrespective of draining; and to require a tenant to bury a portion of his already insufficient capital beneath the soil in drainage under such circumstances, can only lead to the injury of both his landlord and himself.

Up to the passing of the first act for the advance of public money for the purpose of draining, in 1846, the operation of draining, or bush-gripping, as it was more appropriately called, was looked upon as an act of husbandry to be performed by those tenants who had sufficient capital to undertake it at a cost of from 30s. to 40s. per acre.

Though the drainage lasted but 12 or 14 years, the outlay was proved to be remunerative, and such draining was recognised by custom in several counties as an improvement entitled to compensation between outgoing and incoming tenants. Now, so long as the intelligence of the country remained insensible of the manifold advantages of deeper draining, and so long as the operation was covered by an outlay of 30s. or 40s. per acre, we can readily understand that little necessity existed for any participation of the landowner, but as soon as it was established that the best effects of draining depended upon permanency of execution, and could only be gained by an outlay approximating £5 an acre, the matter assumed much more serious proportions. It was no longer a simple process of husbandry. The act of the tenant, dictated by self-interest, rightfully became the act of the landlord, ruled by principle. The only thing wanted was the means of borrowing money, and of adjusting the outlay between present and future owners in cases where the existing owner had but a limited interest in the land.

Mr. Pusey's act, of 1840, was the first public effort made to meet this want, and although the act itself, from its complications, remained inoperative, it effectually established the principle of enabling landowners with limited interests to borrow money for draining, and to charge it upon the lands improved. Mr. Pusey's act, however, was followed in 1846 by the first public money drainage act, and, subsequently, by other acts, including the Private Money Drainage Act, and the three several acts for incorporating the existing private companies.

The desideratum of money was thus fully supplied, and it is much to be regretted that greater use has not been made of the facilities so afforded, particularly during years like the present, when high prices are making tenants more than ever solicitous to increase their profits by hav-

ing draining done, and when they will gladly pay the interest by which the cost will be liquidated, as well as a proportion of the extra expense of doing it at a period of scarcity. I am led to these remarks because I am made daily cognizant of the fact that there are many landowners who, being deterred by the present high prices of labour and materials, are contented to receive their rents without default, and leave the work of drainage to be done inefficiently by the tenant, or defer it to a time when they may possibly be obliged to do it without receiving interest, for it is manifest that the time is not very distant when clay lands will be deemed untenantable so long as they remain undrained.

The several acts referred to gave different powers, but all confirmed the rule that under-drainage was the legitimate work of the owner, and that the only contribution to be made by a tenant should be the payment of the annual instalment by which the cost may be repaid in a given number of years. Beyond establishing this equitable arrangement between landlord and tenant, the obligation enforced on the borrower of money, to show that "the improved annual value shall exceed the amount of annual charge by which the cost of drainage shall be repaid," furnished a very wholesome and just criterion by which any landowner may be guided in the outlay of his own money in draining. In fact, the principle involved in this obligation should be made the rule in every case of improvement. It is not sufficient that an owner spending his own money should get simple interest, he must get so much more than interest as will enable him to establish, if he thinks proper, a sinking fund to repay him his capital within the period for which the work will last, —or the projected improvement is not worth doing.

But as the fulfilment of this principle involves a compact between two parties, the owner who provides or borrows the capital to execute the work, and the tenant who repays it with interest, it is desirable to adopt every means to reduce the annual instalment as low as is just and equitable, without decreasing the efficacy of the work, in order that the tenant may feel that, *in adverse as well as in prosperous times*, he will be able to pay it. To reduce the instalment, it is necessary to lengthen the term for repayment of the money expended, but this can only be done consistently with the durability of the works. The object, therefore, to be arrived at by both parties is to secure the best effect with the utmost durability. Already it has been made apparent that the short term of 22 years, with all the advantage of the low rate of interest of the Government loan, has necessitated a charge upon the tenants which many, even of the most enlightened, are indisposed to bear as a standing increase of rent,—or it has caused dissatisfaction on another and worse ground, viz., that the works themselves have been inefficiently done, from a predetermination to limit their cost to such an amount as will be repaid by a given charge.

I refer to the experience of this fact, because it is manifest that the extension of the art of draining will very materially depend upon the rate of instalment charged upon the tenants, and however profitable individual cases of drainage may be shown to be, the benefit to the nation will be unappreciable, unless we satisfy the tenants generally that during all the vicissitudes of times they can afford to pay the increased rent they are to be charged. The advantage of a lengthened period will be shown by comparing the increased rent a tenant would have to pay to liquidate the expenditure of £5 per acre in 50 years and 25 years. In the former case the increased rent would be from 4s. 6d. to 5s. 3d. per acre,* and in the latter from 6s. 6d. to 7s. 2d. The difference is nearly 50 per cent. Now if drainage is substantially done, there is no reason whatever to doubt that it will last at least 50 years, and it follows, therefore, that the time for repayment may extend, if need be, to that period. (See Note at end of paper.)

In saying thus much on behalf of the general advantage of keeping down the annual charge, I have been led to do so more from a desire to assist in determining who are the proper parties to perform the work of underdraining, than from a wish to underrate the benefit or profit arising from it.

I am in possession of some remarkable instances of the increase of produce, but it would answer no good purpose to give the details now.

I may, however, state in general terms that while many of my correspondents speak of the increase from draining as one-fourth of the produce grown on the same land in an undrained state, *none lay it at less than four bushels per acre.* Some lay great stress on the advantage of doing away with summer fallowing, and in prolonging the wheat seeding time in autumn, and in gaining an earlier fortnight in the spring and at harvest-time, estimating the gain in these respects at a greater amount than the increase in cropping. Some farmers dwell on the reduction of horse-labour; others, again, on the convertibility of drained land, and the capability of folding upon it;—showing, most satisfactorily, that it is not necessary to stretch after every item of gain to enable a tenant to pay a fair per centage on the cost. But among the many facts and opinions I have collected, I know of none that will carry with them greater weight than those afforded by Mr. Hutton, of Gate Burton, in Lincolnshire, whose practical knowledge of agriculture is so well known to all. The following is a letter I have received from him:—

"Gate Burton, November 21, 1854.

"MY DEAR SIR,—As our drainage contract is now nearly completed, I think you will be desirous to know my opinion of the way in which the work has been carried out, as well as the results. I am very glad to be able to give you a most satisfactory report of both. The soil, as you know, is generally clay, with a more porous clay subsoil at a depth of about 3ft. 6in. We have strictly carried out your principles, viz, a minimum depth of four feet, as few out-falls as possible, all of which are well-protected by brickwork, and grated iron outlets, with a fall into the open ditch of not less, if possible, than six inches. It is only common justice to Mr. Wright, who has carried on the work under your superintendence, to say that it is scarcely possible that it could be better done, and I am very willing, nay anxious, to submit it to the closest inspection. With regard to the results, the improvement is wonderful. Where four horses have frequently had considerable difficulty in ploughing, sheep are now eating off a good crop of turnips; and on the old grass land, formerly scarcely of any value to the tenant, the improvement is still greater, as it is now producing excellent crops of wheat, worth almost the fee simple of the land in an unimproved state. —Yours very truly, "W. HUTTON."

I may observe that a large proportion of Mr. Hutton's drainage was done in substitution of shallow draining.

To understand clearly the advance made in underdraining, and the extent of work yet to be done, the whole country should be divided geologically into three great characteristic areas, viz., the western and north-western or Alpine district of primary and transition rocks; the middle district of secondary strata, exclusive of, and up to the lower margin of the chalk; and the eastern and south-eastern district, comprising the chalk of the upper secondary strata, the Wealden and the tertiary and post-tertiary deposits overlying the chalk. There are several outlying portions of the formations thus classified which will be found beyond the line of division, but they are so small as not to interfere with the general arrangement.

A curved line drawn from Exeter to Berwick will make a very close give-and-take division between the western and middle districts; and the lower margin of the chalk, commencing at Weymouth in Dorset, and ending at Flamborough Head in Yorkshire, will form a

* Five shillings per acre increased rent will be met by the following increase of produce, upon a 4-course system of husbandry, independent of all benefit from the improved condition of the soil for tillage and seeding:—

Turnips,	20	bushels	at 3d.	per bushel.
Barley,	1½	"	4s. 0d.	"
Beans,	1½	"	3s. 9d.	"
Wheat,	½	"	6s. 8d.	"

defined boundary between the middle and eastern districts.

1st. The western and north-western or Alpine d strict includes the mountainous granite, mica, and slate rocks with the trap rocks, clays,—and debris associated with them,—and the conglomerate, clay, and loam of the old red sandstone which cover a wide breadth of the lower lying portions of the district.

The district is made up as follows:—

TABLE I.

Name of County.	Extent of each County included in district.	Extent of Land cultivated and Land capable of improvement.	Proportion of wet Land.	Amount of Money applied for under the Public Money Drainage Act.	Amount expended under the Act.
	Acres.	Acres.	Acres.	£.	£.
Cornwall	851,200	680,000	255,000		
Devonshire, part of Somersetshire, part of	1,657,200	1,215,000	400,000	63,702	27,040
Wales, part of	4,000,000	2,997,000	1,250,000		
Monmouth Worcester Hereford ... Salop ..... parts of	1,315,040	1,215,000	750,000	223,863	83,297
Lancashire Yorkshire Northumberland Westmoreland... Cumberland..... parts of	1,035,000	565,000	360,000		
Scotland, part of	18,000,000	9,628,390	5,000,000	1,941,168	1,165,683
Outlying portions in the Midland district	35,840	20,000	10,000		
Total .....A	26,894,280	16,320,390	8,025,000	£2,228,733	£1,276,020

The system of drainage applicable to this district being for the most part occasional or "spring drainage," the expenditure will be brought rather below the cost of parallel or uniform draining. Where parallel drainage has been deemed necessary in the valleys of the granite district, the cost has been generally high, owing to the large quantity of boulder stones and rock fragments which crowd the debris of which the soil is constituted.

In the clay slate valleys, too, the cost has been found to be very great, owing to the necessity of breaking through and blasting protruding rocks, frequently bringing the cost as high as £7 or £8 per acre.

The drains in the hill sides, however, being at comparatively wide intervals will be executed at from £2 10s. to £4 per acre, and the average cost of the whole will thereby be much reduced. It may be assumed that the quantity of land permanently drained in this district by means of borrowed capital and by private outlay, does not exceed 500,000 acres, and that £35,000,000 will be required to perfect the under-draining of the remaining 7,525,000 acres of wet land.

2nd. The middle district, including all the secondary strata from the basis of the Devonian, Cambrian, and Cumbrian ranges up to, but exclusive of, the chalk formation, comprises the mountain limestone, the coal measures, the new red sandstones, and magnesian limestone, the lias, the oolitic strata, and the portion of the green sand with the gault lying to the west of the main ridge of chalk. In these several formations, clays abound sometimes of very considerable width and thickness, and sometimes only thick enough to act as a parting between beds of porous rock, sand, and gravel. Boulder, or transported clays, frequently cover the foundation rock and out-cropping clays.

The following counties, parts of counties, and parts of Wales and Scotland, (See Table II.) make up the middle district:—

This district, consisting of nearly nineteen millions of acres, comprises soils of every degree of tenacity and porosity, from the stiffest clays to the freest sands. About one-half or eight millions of acres of the cultivated lands, and lands capable of improvement, are believed to be either clays or loams requiring drainage on the parallel system, with more or less distance between the drains, and about 3¾ millions of acres are of comparatively porous matter, which require occasional drains, or drains at very wide intervals, to free them of the water upheld by the underlying clays. Some of the stiffest clays, however, particularly patches of the red sandstone clay, some deep beds of the lias and Oxford clays, and the gault, require very close drainage to be effective. An interval of six to eight yards is quite wide enough for these soils. The necessity of thus increasing the number of drains in some places will counterbalance the comparatively small cost of the occasional drainage of the water-logged strata, and will bring the average cost of the whole to £5 per acre. We cannot assume that there are less than ten millions of acres in this district still to be drained. This is, supposing that 415,000 acres have been already permanently drained, and on such assumption it will require £50,000,000 to perfect the under-draining of the district.

3rd. The eastern district includes the chalk (the uppermost formation of the secondary strata)—the green sand which surrounds the Weald clay—the Wealden clay, and Hastings sands, the London and plastic clays,—the Bagshot sand and associated clay,—the crag of Norfolk and Suffolk, the rich deposits of Holderness in Yorkshire, and the more recently recovered fens of Norfolk, Cambridgeshire, Huntingdonshire, and Lincolnshire. Boulder and transported clays are very frequently found in this district also, covering the out-cropping strata.

The following counties or parts of counties (See Table III.) make up the district:—

A very wide portion of this district is chalk, and requires no draining. A considerable portion, too, consists of the fens, of which I have estimated only half as requiring under-draining. Already the prejudice against under-draining these lands is giving way, where the vegetable matter is shallow and the underlying clay comes closer to the surface. The deep peat, or "black fens," may be considered sufficiently well-drained by open dykes, and have not been included in the foregoing statement. I may remark, however, that where under-drainage has been tried, it has been found to consolidate the soil and improve the quality and weight of the corn grown. The whole breadth of the fens in the several counties is about

700,000 acres. Of the denser clays, we have in this district the Wealden and the London clays; the former of which covers 650,000 acres, and the latter 1,500,000 acres, all of which requires parallel and close drainage. Besides these clays, we have a very large space covered with the clays and loams of the Bagshot sand, and with boulder and diluvial clays of every degree of tenacity.

TABLE II.

Name of County.	Extent of each County included in district.	Extent of Land cultivated and Land capable of improvement.	Proportion of wet Land.	Amount of Money applied for under the Public Money Drainage Act.	Amount expended under the Act.
	Acres.	Acres.	Acres.	£.	£.
Devon ... Somerset Dorset ... parts of	1,200,000	1,170,000	650,000	252,678	125,955
Gloucester Monmouth Worcester Salop and Wales ... parts of	2,434,080	2,340,000	1,350,000		
Lancashire ... Yorkshire ... Morthumberland Westmoreland ... Cumberland ... parts of	5,920,120	5,387,000	3,000,000	704,831	442,062
Durham	702,080	650,610	400,000	106,174	64,101
Scotland, parts of	1,352,320	1,200,000	700,000	640,000	314,000
Lincolnshire Norfolk ... Cambridge .. Huntingdon parts of	1,321,040	1,286,000	800,000	158,133	70,113
Bedford ... Buckingham parts of	488,640	450,000	250,000		
Oxford Berks .. Wilts .. parts of	1,020,000	965,000	600,000		
Warwick	574,080	525,000	350,000	20,525	16,189
Northampton ...	650,240	620,000	375,000	27,208	13,108
Rutland	95,360	90,000	40,000	100	
Leicester	500,000	480,000	250,000	17,385	12,155
Nottingham	535,680	510,000	300,000	39,792	16,952
Derby	657,920	590,000	300,000	9,550	3,261
Stafford	757,760	720,000	550,000	39,200	28,930
Cheshire	673,280	630,000	500,000	37,104	23,234
Total ... A	18,882,600	17,613,610	10,415,000	£2,052,680	£1,130,080

TABLE III.

Name of County.	Extent of each County included in district.	Extent cultivated and capable of improvement.	Proportion of wet land.	Amount of Money applied for under the Public Monies Drainage Act.	Amount expended under the Act.
	Acres.	Acres.	Acres.	£.	£.
Dorset Wilts. Berks. Hants. Oxford parts of	2,203,840	2,130,000	600,000	55,473	21,313
Bucks and Beds, parts of	280,000	265,000	250,000		
Cambridge and Hunts, parts of..	546,560	519,000			
Hertford	403,200	375,000	300,000	18,750	17,363
Middlesex	180,480	160,000		10,625	3,176
Surrey	485,760	450,000	1,300,000	29,155	13,155
Sussex	938,240	900,000		52,768	22,253
Kent	996,480	940,000		23,020	8,293
Essex	981,120	940,000	650,000	21,805	6,782
Suffolk	969,600	920,000	700,000	8,990	5,495
Norfolk, part of	1,285,360	1,215,000		18,260	6,853
Lincoln, part of	600,000	550,000	600,000	35,000	18,000
Yorkshire, part of	450,000	425,000			
Outlying portions on the Western side	254,480	235,000	50,000		
Total ... A	10,575,120	10,024,000	4,450,000	273,846	122,683

As the metropolis and suburbs are included in this district, I have assumed that 450,000 acres have been permanently drained, leaving 4,000,000 acres requiring draining, the cost of which cannot be estimated at less than £22,000,000.

The following summary gives the totals of the districts:

TABLE IV.

DISTRICTS.	Total Extent.	Extent cultivated and capable of cultivation.	Proportion of wet land.	Amount of money expended under the Public Money Drainage Act.	Amount of money expended under the Private Money Drainage Act.	Estimated Amount of money expended by Incorporated Companies.	Estimated extent of Land drained permanently by borrowed money and by private means.	Extent still remaining to be drained.	Estimated amount of capital required.
	Acres.	Acres.	Acres.	£.	£.	£.	Acres.	Acres.	£
Western and North-Western District	26,894,280	16,320,390	8,025,000	1,276,020	128,723	350,000	500,000	7,525,000	35,000,000
Middle District	18,882,600	17,613,610	10,415,000	1,130,080			415,000	10,000,000	50,000,000
Eastern District	10,575,120	10,024,000	4,450,000	122,683			450,000	4,000,000	22,000,000
Total	56,352,000	43,958,000	22,890,004	2,528,783	128,723	350,000	1,365,000	21,525,000	107,000,000

I have to thank the Inclosure Commissioners for the figures I have quoted relating to the advances under the Public and Private Money Drainage Acts. Having transposed them for my own purpose, I think it best to give the totals with which they have so obligingly furnished me in another form. They are brought up to the 31st October last:—

TABLE V.

	PUBLIC MONEY		PRIVATE MONEY	
	Applied for.	Expended.	Sanctioned.	Expended.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
England	1,940,227 11 6	1,059,804 0 0	292,056 0 0	111,098 0 0
Wales	123,863 0 0	44,297 2 1		
Scotland	2,491,167 16 6	1,424,682 17 6	72,083 0 0	17,625 0 0
	4,555,258 8 0	2,528,783 19 7	364,139 0 0	128,723 0 0
To expend		1,471,216 0 5		
Total amount of loan		4,000,000 0 0		

Thus we see that there will still be required £107,000,000 for the under-drainage of Great Britain, towards which the balance in hand of the Government Loan, £1,471,216, is applicable, leaving the sum of £105,528,784 to be provided from private sources. Of this it may be assumed that four-fifths, or about £80,000,000, will be required on loan, and that the collected capital of incorporated drainage and insurance companies will be the future source of supply; for it is hardly to be supposed that the legislature will again sanction the advance of public money for the particular benefit of one class of the community, after experience has shown that private companies are able and willing to lend money upon the lowest rate of interest ruling in commercial affairs.

The sum of £80,000,000 appears large when placed in juxta-position with the Government loan of £4,000,000; but, when compared with the sums expended in other national enterprises, such as the £286,068,794 expended within the last twenty-five years by railway companies, it cannot be so regarded, particularly if we remember that 3½ per cent. is above the average interest now gained by railway investments; whereas, in drainage advances, not only would the capitalist be made secure of the current interest of money by a first charge on the freehold itself, but both the owners and occupiers of land would derive a paramount advantage from an enterprise in which they practically run no risk and advance no capital. And, while this result would be gained by individuals, the community would be benefited by an increase in food, by drainage alone, which cannot be estimated in the aggregate at less than 5,330,000 quarters of the several kinds of corn which constitute the country's produce.

The public loan being all bespoken, the means of borrowing money now at command of landowners are:—The Private Moneys Drainage Act (12 and 13 Vict., cap. c.), the term for repayment being 22 years; the West of England, or South West Land Draining Company's Act (11 and 12 Vict., cap. cxlii.), under which a landowner may charge his estate in perpetuity; the General Land Drainage and Improvement Company's Act (12 and 13 Vict., cap. xci.), the term for repayment being 50 years; and the Lands Improvement Company's Act (16 and 17 Vict., cap. cliv.), the term of repayment being 25 years.

Having explained how under-draining became the obligation of the landlord, when it was converted from a temporary to a permanent work, and having shown the source whence borrowed capital is to be obtained, and how little progress we have made in comparison with what still remains to be done, I will pass to those results which the actual practice of the last ten years afford, and which will influence our future mode of executing works of drainage.

In order to trace the progress now making towards the realization of that adequately deep drainage which Dr. Lyon Playfair has so well described in the article "Theory of Drainage," in the Cyclopædia of Agriculture, we must have reference to the relative merits of the several methods which have been propounded in direct opposition to or as a compromise of the principle of depth.

First on the list is the shallow-draining system, which admits the use of pipes in lieu of bushes, but adheres to drains 18 to 24 inches deep in the furrows, as the quicker means of getting rid of water falling on the surface, than drains laid at a greater depth. I do not propose to dwell very long on this system, for so numerous are the instances throughout Great Britain of the complete success of deep draining, when properly executed, and so generally is deep draining now substituted for shallow draining, that

it is difficult to admit of a compromise of depth under any circumstances whatever. But as the advocates of shallow draining have been enabled, by certain defects in the development of the deep-drainage system, to maintain a position for a time, it is advisable to trace at once the causes of such defects, that we may not be led away from true principles by accident or the influence of prejudice. We cannot hide from ourselves that the operations under the first Public Money Drainage Act were stimulated by erroneous notions of economy. It was thought that the greater part of our clay lands would be drained at a cost of £3 or £4 per acre, or even less, and to this delusion may be attributed the greater part of the defects which have brought discredit on the system. Experience has shown that the average cost of adequately deep drainage is as near as possible £5 per acre, although at this time the general increase in the price of labour and materials has increased it to about £5 15s. 0d.

Drainage, to be perfectly satisfactory in its effect upon the soil, must render it uniformly permeabie to the full depth of the drains. The soil midway between them must be in the same condition to receive and infiltrate the rain that falls upon it, as the soil nearest the drains. If this be not accomplished, they are not producing that united effect which should be sought for and obtained, and there is no more certain way of producing *an irregular condition of soil*, than by placing the drains so far distant from each other, that the influence of one drain cannot perfectly meet the influence of another.

Cases have been quoted as failures of deep-draining, in which a desire to keep down the cost has led to an indiscreet widening of the distance; and the unsatisfactory result to which I have referred, following that indiscretion, has proved that the increased depth of drains will not compensate for increased distance, and that soils which should be drained 24 feet apart, cannot be sufficiently well drained at 40 feet apart, let the depth be what it may. But the effect has been no other than this,—the principle of depth has remained unshaken. It has simply proved that good draining is not to be done for as little money as bad.

Among the instances of this species of partial failure, I may state that I have been obliged in several instances to introduce intermediate drains when I have been over careful of expenditure, and have placed those first laid out 30 feet, where they ought to have been 25 feet apart.

Mr. Gow, of Morpeth, writing to me last year said, "I have had one or two failures in deep-draining, where, from a desire to economise, I have placed the minor drains at too great a distance apart; and I find, too, that some of our earlier performances, at a depth of three feet, will require to be re-drained at a greater depth."

It is a common assertion, "that water cannot get down through clays," but in no one instance has it been successfully shown that water will disobey the laws of gravitation, or will fail to descend through *any clay soil, however absorbent and retentive*, to an approximate level with drains of reasonable depth (not less than four feet), *if they be placed sufficiently near each other* to counteract such absorbent and retentive properties, and to meet the effect of atmospheric humidity in maintaining them in force.

Frequently has it fallen to my lot to meet men retaining prejudices in favour of shallow draining, on clays which they have declared to be so stiff and retentive, that it was impossible water could find its way down, and so dense and dry in the subsoil, that no water could be gained from cutting into it. These clays have nevertheless been drained from four to five feet deep, and water has flowed copiously from the outlets; still the advocates of shallow draining, when asked "from whence comes the water?" reject this simple proof of their error.

In the same way they refuse all evidence of the superior effect of deep drains afforded by the facts that they generally commence running *before* shallow drains; that they invariably run as soon and *more copiously* than shallow drains; that they continue to run long *after* the shallow drains have ceased to run; and that they discharge *clear* water, while the shallow drains discharge discoloured water, showing how perfectly the former act as a means of conveying to the subsoil (which the shallow drains hardly penetrate) a proportion of the manure the farmer has taken the pains to put on his land, but of which he is robbed by his shallow drains. If the advocates of shallow draining cannot adduce any instance of the failure of deep draining, it cannot be said that no instance can be found in which shallow draining has failed to keep even the surface of land dry, leaving out of consideration the many benefits incidental to deep drainage, and which are altogether lost sight of, but which are of equal importance with drainage itself.

The following extract of a letter will show that land carefully drained 18 inches deep with tiles, becomes, in a few years, as wet or even wetter than before.

It is from Mr. Macvicar, of Barkwith, in Lincolnshire. He says—

"I have met with several cases of shallow drainage which at first have been followed with beneficial results, and have become after a time inoperative. Thus, in the parish of Colsterworth, a field of strong retentive clay land was drained in 1842, at a depth of 18 inches; for a time the land was apparently laid dry, but in succeeding years it showed symptoms of returning wetness.

"I saw the field last week; it is sown with wheat, and, although water-furrowed, the land is saturated with water. I examined the outlets, which were running very slowly, although I believe the drains are open."

I have never yet heard a satisfactory reason for land returning to a state of wetness after being dry. One thing, however, is proved by Mr. Macvicar's case, and that is, that it is not merely by the substitution of the durable pipe for the perishable thorn that the surface of land can be rendered permanently dry, as the shallow drainers say. It will be observed that it is about 14 years since this specimen of *permanent* shallow draining was done. This length of time accords with the period which is generally understood to be the time which elapses before bush-draining would be renewed. Now, I have often heard the remark from farmers who were about to renew this latter description of draining, that they could not account for the land becoming so wet as to require re-draining, when their drains which were put in 12 or 14 years back were open and running, but such was the case; and I believe it will be found that pipe-draining 18 inches deep, will be as little durable as bush-draining of the same depth; for whether it be from increased succullency of the surface soil, or from any other cause this discussion may elucidate, it is certain that time will render shallow drainage useless without any rupture of the drains themselves.

Before leaving the shallow-draining system, I will take the liberty of referring to a circumstance which, I trust, will prove to Mr. Bullock Webster, who has long advocated shallow-draining, that he has been misled, and by that he has inadvertently misled others.

In 1850, Mr. Webster published, in the *Journal of the Royal Agricultural Society*, a short paper, headed "Mischief arising from Draining Clay Soils too Deeply," and without giving any proof whatever of the mischief to which he referred, he gave currency to what the agent of the Duke of Wellington was doing, and quoted a letter, signed by Mr. Charles Easten, in which he said it was intended never again to put a drain upon the heavy clay at Strathfieldsaye at a greater depth than three feet. I presume he meant to convey that these clays could not be drained effectively at four feet deep or more. It fortunately happened that the Speaker of the House of Commons, whose estate at Heckfield is intermixed with that of the Duke, determined in 1852-3 to drain a portion of his estate. He employed the General Land Drainage Company to do the work for him, and instead of draining at Mr. Easten's depth of three feet, the Company have not laid a single drain less than four feet deep, and the major portion have been laid four feet six inches and more.

So prejudiced were the tenants against deep drainage in the first instance, that they threw obstacles in the way, and the Speaker kindly limited the work to one farm. When this was done the tenants, one and all, begged that the wet lands of their several farms might be drained, and the Speaker thereupon entered into a second contract for several hundred acres, allowing them to select, as far as was practicable, the lands they called "*wet*." On the completion of this second contract, the tenants, with the same unanimity, but with increased earnestness, begged to have the very lands drained they had withheld as dry, and not requiring draining, because they found by comparison with the drained land—the "*mischievously*" deep-drained land—that the excepted dry land was insufferably wet, and to oblige his tenants, the Speaker has just entered into a third contract.

I have passed over the clays of Strathfieldsaye, and I can recognise no difference between them and the clays of Heckfield.

I will not dwell upon the tangible evidence the instance affords of the efficacy of deep drainage, nor the contradiction it gives to the reputed "mischief" arising from the practice.

It must be manifest, I hope, to Mr. Webster and to those who generally agree with him.

As an advance upon the extremely shallow drainage of 18 inches and 24 inches depth, we find Mr. Denison, Mr. Milward, and several other gentlemen of high repute, draining from 2 feet 6 inches to 3 feet deep, and they still, I believe, express themselves satisfied with the result; but, as drains of the medium depth of 2 feet 6 inches to 3 feet cannot fail to do some good (and, perhaps, a lasting one, so far as the discharge of water goes), the fact that the result has been satisfactory to those who performed the work, does not prove that such medium depth is the best. On the contrary, I hope, by referring to a few facts, to show that drainage as shallow as 30 inches or 36 inches, fails to provide for all the objects in view.

Three important advantages attend deep drainage beyond the primary object of discharging superfluous water. The first is—the increased quantity of soil ameliorated and rendered serviceable to vegetation; the second—its improved temperature; and third—the removal of the pipes beyond the reach of deep cultivation, and beyond the reach of *annual* vegetation, to stop the drains by the growth of roots within them. With regard to the first advantage, it can hardly be necessary to say that the staple of aërated soil, into which the roots of plants can travel and seek their food, cannot be too deep. Every inch of additional drainage gives 100 tons of active soil per acre, rendered, by drainage, so free and porous, as to gain fertility from the rain passing through it, and from the solution of the ingredients of the soil, and from the manure which is brought down from the surface by the rain.

I published recently some very curious illustrations of the dislike plants exhibit for stagnant water in the soil. They afforded proof that directly the roots reach the standing water level, they ceased to penetrate further. I have evidence now before me that the roots of the wheat plant, the mangold wurzel, the cabbage, and the white turnip, frequently descend into the soil to the depth of three feet. I have myself traced the roots of wheat nine feet deep. I have discovered the roots of perennial grasses in drains four feet deep; and I may refer to Mr. Mercer, of Newton, in Lancashire, who has traced the root of rye grass (which is daily coming more and more into cultivation) running for many feet along a small pipe drain after descending four feet through the soil. Mr. Hetley, of Orton, assures me, that he discovered the roots of mangolds in a recently-made drain five feet deep; and the late Sir John Conroy had many newly-made drains four feet deep stopped by the roots of the same plant.

These facts are mentioned to show that the roots of our cultivated crops do descend and appropriate the soil to as great a depth as they are permitted, and we have proof, too, that the greater range of active aërated soil we can give them, the more prolific and weighty is the grain they produce. This has been satisfactorily shown at Yester. By deep cultivation the produce of the wheat crop there has been increased from three quarters and six bushels, to five quarters and four bushels, and the weight per bushel in proportion. Instances could be given of advantages arising from the removal, by deep draining, of the injurious presence of oxide of iron which is known to pervade many of our clay soils, but I refrain from multiplying cases which may appear at all speculative or incapable of proof.

Upon the second point, the temperature of the soil, we have at present no positive evidence to show that any advantage is gained by increasing the depth beyond three feet, but it cannot, nevertheless, be doubted, that the deeper the drainage which regulates the height of stagnant water in the soil, the more likely it is that excessive evaporation, and its chilling effects in the soil itself, will be prevented. Mr. Parkes has clearly shown, in his admirable paper in the 5th Volume of the *Journal of the Royal Agricultural Society of England*, the loss of heat by evaporation of water in undrained land. The experiments carried on at Yester, show, that in winter a higher temperature of 2° 25′ was gained by draining, while in summer there appeared to be no gain. By the act of deep cultivation, however, in addition to draining, a gain was effected of 2° in summer and 4° 25′ in winter. In this case the drainage was only 33 inches deep, and the comparisons of heat were not made on the same land before and after draining, but on adjoining lands. What would be the effect of an adequately deep drainage has not yet been communicated, though I believe that experiments are in progress which will show that a higher temperature can be produced than any that has attended drainage only 33 inches deep.

But as a proof of the sensibility of a soil drained four feet deep to atmospheric changes, I may mention that my attention has been on more than one occasion called to the circumstance that drains have been observed to run after a discontinuance of that duty without any fall of rain on the surface of the drained land, and upon reference to the barometer, it has been found that the quicksilver has fallen whenever this has occurred. Mr. George Beaumont, jun., who first afforded tangible evidence of this extraordinary circumstance, has permitted me to read the following extracts of his letter:—

"I can verify the case of the drains running without rain during a falling barometer beyond all doubt.

"The case I named to you last year of the barometer falling four days consecutively, and with rapidity, was a peculiarly favourable time for noticing it, as it occurred in a dry time, and the drains could be seen distinctly. My man, on being questioned and cautioned by me not to exaggerate, has declared the actual stream of water issuing from one particular drain to be as thick as a $\frac{5}{8}$-inch wire. All the drains ran—they did more than drop—and ditches which were previously dry became quite wet, with a perceptible stream of water; this gradually ceased with the change in the density of the atmosphere, as shown by the barometer.

"During last harvest, 1855, the men were cutting wheat, and on getting near to a drain outlet, the ditch from the outlet downwards was observed to be wet, and the drain was dripping. No rain fell in sufficient quantity to enter the ground. The men drank of the water while they were cutting the wheat. A few days after it was dry again. I have seen and noticed this phenomenon myself."

A correspondent of the *Agricultural Gazette* has stated that Professor Brocklesby, of Hartford, in America, had observed the same phenomenon in the case of two springs in that country, and explained that the cause was "the diminished atmospheric pressure which exists before a rain."

With respect to the third point, I wish to avoid speculative views as to the extreme depth to which cultivation may reach, but I believe with the present mode of subsoil ploughing (without the aid of steam-power

which is advancing upon us) a depth of from 17 to 22 inches is gained; it is, therefore, obvious, that pipes laid 18 inches deep would be lifted by the plough, and it is not improbable that when we have the aid of steam-power, pipes laid 24 inches deep will be moved as readily. With these anticipations it would be a very bad provision for futurity if the owner of entailed property called upon the next generation to contribute to the cost of draining at any depth which 20 years hence may appear as shortsighted as drainage 18 inches deep is now deemed to be. It is true that pipes laid 3 feet deep may not be directly touched by the instrument of subsoil ploughing, but we have evidence of the disposition of the roots of plants to thread their way through *stirred* soil 4 and 5 feet deep, and of the stoppage of pipes by the roots of cabbages, mangold wurzel, and turnips, at a depth of 3 feet, *where the soil is firmly consolidated.* With this experience it must be admitted that the insecurity of 3 feet drainage will be increased by subsoiling, and that therefore the adoption of such a medium depth may operate as a bar to an improvement which may become a natural sequence to draining.

I trust that these few remarks—difficult to condense—in explanation of the collateral and secondary benefits of deep drainage, will serve to show, that in the aggregate, they are of equal importance to the primary object of discharging injurious water, and that any system of drainage which does not provide for them is imperfect as a permanent work.

With these observations I will pass to that system of draining which has recently acquired the title of the *Keythorpe system.* Allowing for a difference in the mode of carrying it into execution, this method is based upon the same principle as Mr. Baker, of Writtle, has enunciated, viz., that if there be a porous soil only 2 feet deep, resting on an impervious subsoil, nothing is gained by carrying the drains into the latter. All practical men—I mean practical men, *qua* drainage—will at once dispute the assumption that there exists any clay subsoil at a depth of 2 feet below the surface which is impervious, and that, therefore, any system founded on it is nothing more nor less than an indirect mode of shallow draining, aiming only at the discharge of water, without seeking any of those collateral advantages just referred to.

The Keythorpe system, which has been very ably explained by Mr. Joshua Trimmer, the eminent geologist, in the *Journal of the Royal Agricultural Society*, is brought before agriculturists with the flattering recommendations of cheapness and scientific treatment. Lord Berners, the owner of the Keythorpe estate, having certain lands in hand, commenced his draining operations by causing numerous holes to be dug. By observation and experiment, which appears ultimately to have led to a definite practice, his lordship was enabled to arrange his drains so far distant from these holes as just to suffice to draw the water out of them. Mr. Trimmer explains the mode adopted to be a system of draining by pipe channels transverse to certain ridges and furrows, found to exist between soil and subsoil, or, to use the words of Mr. Trimmer, "between the warp drift and the erratic tertiaries of the older strata, on which the warp drift rests" with a view to intercept the water which finds its way through the porous warp drift into the furrows; these furrows acting, in fact, as *minor* drains to the transverse channels, which act as *sub-mains.*

The characteristics of the system are:—

Firstly. That the drains are neither equidistant nor of regular depth, their position and depth being determined by the shape of the subterranean undulations and the depth of the furrows.

Secondly. That the drains cross the line of greatest descent (obliquely) in order to intercept the water flowing down the furrows referred to, "which are generally found," Mr. Trimmer says, "on land with a considerable fall, and run, in most cases, in the direction of the fall; and,

Thirdly. That the efficacy of the drainage depends upon a precise knowledge of the breadth and depth of the ridges and furrows.

Without venturing to deny the statement of so sound a geologist as to the existence of these subterranean ridges and furrows, and without presuming to deny that Lord Berners has rendered his land dry for the time being, I am content to state what appear to me insuperable objections to the general adoption of the Keythorpe system. The first is, that the depth of the drainage must necessarily depend upon the depth of the furrows, whether they be 18 inches or 10 feet deep (if they are found to exist of sufficient regularity to become applicable as drains at all). We have the evidence of what has been done at Keythorpe, showing that they are sometimes found to lie only 18 inches deep, one-tenth of the drains being that depth.

If, therefore, Lord Berners should follow the example of the Marquis of Tweedale, and determine to subsoil this drained land next year to a depth of 22 inches, he would not only plough up all his 18-inch pipe drains, but, inasmuch as he would decapitate and deform the ridges alternating with the furrows (which are his minor drains), the destruction would not be limited to the 18-inch drainage, but would extend to the major part of the work. The second objection is, that the direction of the pipe drains is across the fall of the land, and, therefore, opposed to the influence of gravitation; and the third is, that there exists no tangible data generally applicable for setting out the pipe drains.

In many instances I am satisfied that the knowledge Mr. Trimmer has made peculiarly his own, would be not only beneficial to landowners, but might frequently assist draining engineers in solving problems in nature, which correct geological knowledge alone can solve. But I do not think it will afford tangible data for the execution of drainage works, particularly those in which expedition forms an item of profit, as is generally the case.

The next system which intervenes as a compromise with the principle of depth, is that of the late Lord Wharncliffe. It is called the combined system of deep and shallow drainage, and has been described by his lordship, in the *Journal of the Royal Agricultural Society*, in the following terms:—

"In order to secure the full effect of thorough drainage in clays, it is necessary that there should be not only well laid conduits for the water which reaches them, but also subsidiary passages opened through the substance of the close subsoil, by means of atmospheric heat, and the contraction which ensues from it. The cracks and fissures which result from this action, are reckoned upon as a certain and essential part of the process.

"To give efficiency, therefore, to a system of deep drains beneath a stiff clay, these natural channels are required. To produce them, there must be a continued action of heat and evaporation. If we draw off effectually and constantly the bottom water from beneath the clay and from its substance, as far as it admits of percolation, and by some other means provide a vent for the upper water, which needs no more than this facility to run freely, there seems good reason to suppose that the object may be completely attained, and that we shall remove the moisture from both portions as effectually as its quantity and the substance will permit. Acting upon this view then, after due consideration, I determined to combine with the fundamental four feet drains a system of auxiliary ones of much less depth, which should do their work above, and contribute their share to the wholesome discharge, while the under current from their more subterranean neighbours should be steadily performing their more difficult duty.

"I accomplished this by placing my four feet drains at a distance of from eighteen to twenty yards apart, and then leading others into them, sunk only to about two feet beneath the surface (which appeared upon consideration to be sufficiently below any conceivable depth of cultivation), and laying these at a distance from each other of eight yards. These latter are laid at an acute angle with the main drains, and at their mouths are either gradually sloped downwards to the lower level, or have a few loose stones placed in the same intervals between the two, sufficient to ensure the perpendicular descent of the upper

stream through that space, which can never exceed, or, indeed, strictly, equal the additional two feet."

In order to give you the most authentic account of the results of this system, I will read you the following extracts from a letter I have just received from Mr. William Hunt, of Wortley:—

"I am now able to give you my opinion of the success of the same system of draining upon the Carleton property, belonging to Lord Wharncliffe. The combined system has succeeded most admirably there. The soil generally is a strong loam for about one foot in depth, then a stiff clay subsoil, but I found on making trial pits in several parts of each field, that at the depth of about 3½ feet, and between that and 4 feet, the clay was a little more porous, although below that depth it became quite stiff. I, therefore, set out the 4 feet drains according to his lordship's usual practice, by 20 yards apart, with the 2 feet drains slanting into the 4 feet at 8 yards apart.

"The tenants were at first much averse to the combined system, but they are now highly in favour of it in preference to the regular system at whatever depths, and they are now preparing to sow turnips next season where such practice was never thought of previously. The rapid manner in which the surface has become dry after the heaviest falls of rain, has quite surprised all parties who have witnessed the effects of the combined system of draining at Carleton. *I have no doubt but 4 feet drains, placed at regular distances, would have drained the land I have named, but the cost would have been much higher, and what is of greater importance than the expense?*

I desire to draw your particular attention to the last paragraph of this letter. My kind correspondent could hardly have made a more candid admission of the influence of expediency.

It would only be repeating the observations already made, were I to explain the several objections with which practical drainers regard this system. I may shortly observe, however, that no one would contradict that the lands were improved by the method of draining adopted, simply because it would be impossible to deny, as I have before implied, that any drain, even two feet deep, could be put into land without doing some good, but it is equally impossible to reconcile with any laws of hydraulics, engineering, or economy, the union of the two depths in one system. The drains of the greater depth must detract from the utility of those at the less, and the two directions, *with* the fall and *across* it, cannot both be right. The numerous junctions, too, are liable to constant disarrangement. It would appear that, by adopting an uniform depth of three feet six inches (which, although not so good a depth as four feet, is a respectable depth), at intervals of 25 feet, a much more permanent drainage could have been secured for £5 an acre (a sum to which Lord Wharncliffe limited himself), than by any method of which a depth of two feet is an element, if the advantages of uniform aeration and deep cultivation are recognised, considerations which Mr. Hunt would appear to have overlooked in the question with which the quotation closes, and which shows clearly that the combined system is simply one of expediency.

I have avoided the subject of spring draining, because all practical men seem to agree on the principle of action, and the length to which this paper has already extended forbids any further enlargement.

Having described the several systems of shallow draining, semi-shallow draining, subsoil furrow or Keythorpe draining, and the combined deep and shallow draining, we now approach that of the adequately deep draining, and a consideration of the means by which that object is to be obtained at the least cost. But let me premise in distinct terms that there are many who are convinced of the advantages of deep draining (I admit myself to be one) who, when dealing with the poorer and denser clays, yield to the views of the late Sir Robert Peel, when he said that he could conceive a case in which if the amount to be expended was limited, *increased closeness might compensate for diminished depth.* Deep drainers do not admit this compromise, however, because "the surface water cannot get down;" they do so with the candid acknowledgment that they do not like what they are doing, but that inasmuch as the draining of these soils must be as close at one depth as at another, they concede 6 inches in depth, in order to reduce the amount of interest a tenant will be called upon to pay to cover the outlay.

In determining the distance between drains, it is necessary not only to have regard to the nature of the soil, but to the amount of annual rain-fall and the frequency of rain.

A practical knowledge of the different clays of the different formations enables the draining engineer to determine pretty accurately the draining properties of each.

To enable a landowner whose experience is comparatively limited to form a judgment on the subject, I may venture to recommend a means of mechanical analysis which I have found useful, and which I explained last year. (See Land Drainage and Drainage Systems, page 23.) The proportions of sand and clay are ascertained by washing a given quantity in a flat-bottomed medical phial. The sand subsides below the clay and is visible through the glass. The existence of lime is ascertained by means of acid. If it effervesces lime exists, and if the lump dissolves very rapidly, there will be a considerable proportion of lime in the soil. The capabilities of the soil to expand and contract, are ascertained by weighing and measuring a given quantity at different times and under their different conditions of wetness and dryness. In cases of difficulty, recourse should be had to the chemist.

The necessity of a careful examination into the draining properties of clays, will be seen by a statement of the comparative cost of draining at different widths. A single yard too near may be a pound per acre thrown away, while a yard too wide may occasion dissatisfaction for ever. Taking labour at 7d. per rod, and pipes and haulage at 22s. 6d. per 1,000, the cost will be as follows:—

	£	s.	d.
At 18 feet apart	7	18	4
21 ,, ...	6	16	3
24 ,, ...	5	19	8
27 ,, ...	5	6	9
30 ,, ...	4	16	5
40 ,, ...	3	12	1

Experience shows that a consideration of the amount of rain-fall is a matter of much moment in determining the width between drains. It does not appear, practically, to govern the size of the pipes to be used, for if the ends of the pipes can be made to join securely, and the fall is good, the smallest sized pipes will be sufficiently large. But in proportion to the rain-fall, all other considerations being equal, should be the distance of the drains apart, in order that the soil may be sufficiently free at all times to absorb and discharge the maximum amount that can fall on its surface.

We find from sundry careful records, that 141 inches may be taken as the average annual rain-fall of the wettest place in Cumberland, while 19½ inches may be taken as the average fall in Essex.

It is not enough to ascertain the quantity of rain that falls, we should know the prevalent periods of continuance of rain and moisture, for in accordance with the length of time intervening between rains will be the opportunity for soils to undergo those changes of condition which are essential to complete development of draining, and which conduce to an improved "climate of the soil itself."

We find that the average number of days in the year in which rain falls in the wettest districts of Cumberland is 210, and at Castle Hill, in Devonshire, 191 days, while at Chiswick, the average number of wet days in the year is 124, with an average fall of 24 inches.

Fortunately, however, the clay soils of the west and north-west of England are comparatively open and porous, and thus counteract the humidity of atmosphere under which they exist, whereas the denser clays, lying to the east of the lias out-crop, have the advantage of a greatly reduced rain-fall, although the number of days on which rain falls is not proportionately less.

With respect to the direction of drains, I believe very little difference of opinion exists. All the most successful drainers concur in the line of steepest descent as essential to effective and economical drainage. Certain exceptions are recognised in the West of England, but, I believe, it will be found, as practice extends in that quarter, that the exceptions have been allowed in error. There is much difference of opinion as to the adoption of an equi-distant parallel system in lands of the ridge and furrow form. In arable land, the most successful drainers throughout the country disregard the furrows, whereas, we find the majority of those in the Midland Counties leaning to the adoption of the furrows as the course of the drains in grass lands. The same difference of opinion prevails as to the use of collars. Some good drainers object to them on account of the cavity left between the collars, but the majority approve of them, and would use them in all soils were it not for the additional cost. In sandy and gravelly soils they are indispensable. With regard to the admission of air to the heads of drains, as advocated by Mr. Simon Hutchinson, very few think it advisable, while some go so far as to say it is decidedly injurious.

Upon the question of outlets there appears to be much difference of practice where there should be none. In the whole process of draining there is nothing so desirable as permanent and substantial work at the point of discharge, so as to reduce to a minimum the ill effects of inattention on the part of tenants, and the neglect of communication between present and succeeding owners. It is considered that the more frequent the outlets the more active the drainage, but as every additional outlet involves additional cost in erecting and care in preserving them, prudence suggests that the number of acres draining to one outlet should never be more than 20 or less than six, if the form of the land and size of the fields will permit of these limits. On this arrangement, iron pipes, with swing gratings, set in masonry, may be provided at the cost of 1s. per acre. The outlets should be numbered consecutively.

If these several objects be borne in mind in carrying into operation the main principle of *adequate depth*, there will be but little chance of failure. Having perfected the work, one thing still remains to be done. A plan or record of the lands drained, and the position of the drains is necessary; and in order that such a record may be preserved for future generations, it is desirable that a national office, connected with the Tithe and Inclosure Commissions, should be set apart for the purpose. It would be invidious to point out instances in which recent works of drainage have already become useless from change of ownership and the indifference of successors. The cost of planning the drains after execution need not exceed 6d. to 9d. per acre, where a map of the lands already exists, and after we have spent £5 per acre in draining, does it not appear the very height of folly not to preserve a record of so expensive an object at a cost of 6d. per acre.

I cannot leave my subject without congratulating the country generally on a few points of great moment connected with it. First, is the improvement observable in field labourers from their occasional employment in systematic drainage. This improvement is to be particularly noticed in those counties where the wages were lowest and the labourers were esteemed to be inferior. I will instance the counties of Southampton, Wilts, and Dorset. When the General Land Drainage Company first commenced works in those counties, the use of the spade and graft appeared un-familiar to the farm labourers. We introduced labourers at nearly double wages from Northumberland and Yorkshire, to teach them their use, and we obtained more profitable labour from the Northumberland man at 18s. per week, than from the Dorset man at 10s. But the tables are now turned; we have at this moment Dorsetshire men employed at Swine, in Yorkshire, who surpass the Yorkshiremen in the quality and expedition of their work. And as it is known that a good drainer is necessarily a good hedger and ditcher, and a handy man at nearly all field work, we may consider that one good result from a general extension of draining will be to increase the capabilities of the farm labourer, and give him a just claim to better wages.

The next subject of congratulation is the increased healthiness of those districts in which any considerable extent of land has been drained;

And the last is the admission, now becoming very general, that the time has arrived when the main and tributary outfalls throughout the county must receive attention. The whole question is growing daily more and more serious, and I earnestly commend it to the consideration of those who, having influence, are willing to exert it in favour of an object of the highest national importance.

*** Since Mr. Denton's paper was written and in type, he has made the following addition to it:—

I must here refer to some observations made by Mr. Baker, last night, at the Central Farmers' Club, and I do so because it was evident that his words, uttered with all the effect of his high standing as an agriculturist, seemed to strengthen prejudices which are based on error.

He stated that it was impossible that drainage works could be permanent, and instanced a particular case of pipes being silted up though laid three and a half feet deep. Upon my asking him what they filled up with, he told me sand; and, on my asking if the pipes were laid with collars, he said "No."

Now, I need only remark that the whole question of permanency depends on the mode of execution. If gravelly and sandy land is drained only 3 feet 6 inches deep, it is hardly necessary to say that the drainage may be as deficient of depth as 18-inch drains are known to be in clays; and to drain any gravelly and sandy soil without collars, is simply throwing money away. If such works as these afford Mr. Baker the data upon which he declares it is impossible to render drainage works permanent, I can readily concede the fact.

Again, Mr. Baker referred to some works executed by means of the Government loan, and repeating the fact (in which I can corroborate him) that lands of different character have, in certain instances, been drained alike—he was pleased to attribute this to the influence of scientific drainers. Now, what is the fact of the case? The works that have been so executed under the commission, are those which landowners entrust to their own bailiffs, under the *nominal* instructions of the Government Inspectors, who really have no more to do with the actual execution of the works than men can have who are only called in at the commencement and finish. But on this point I hope there are some here who will speak and disabuse the public mind of the fallacy of holding public officers responsible for work requiring such particularity of management as drainage, who, perhaps, may not see it during the whole time of execution.

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DISCUSSION.

The CHAIRMAN was extremely happy in being the medium of conveying the invitation of the Society to those gentlemen present who would kindly favour them with their opinions upon the interesting topic before them; but in doing so he would make the remark, that as their time was extremely limited, and as the different branches and views of the subject were, he expected, numerous, it would be most interesting to learn the experience of as many as possible, and this would be best carried out by gentlemen making their remarks in a condensed form. The subject was not a new one, and the views of each speaker would be rapidly gathered if that plan were adopted.

Mr. JOSHUA TRIMMER said, the remarks which he should make would be confined to the case of drainage upon the Keythorpe system, the principles on which it was founded, and the success which had attended it; and he should endeavour to reply to the objections raised against it, not only by Mr. Denton, but by others, on various occasions. The distinguishing character of that system of draining was, that it took advantage of certain subterranean furrows between the soil and the subsoil. He had for many years pointed them out to geologists as having important bearings upon the changes which the earth's surface has undergone, and to agriculturists with a view to drainage purposes. The last time he had brought them under notice in respect to draining, was in a lecture before the Royal Agricultural Society, on which occasion he pointed out for examination a section of a railway cutting, showing the irregularities which existed in the junction of the soil and subsoil. Those irregularities were the sections of certain channels between the soil and subsoil, of which the Keythorpe system of drainage took advantage, by laying the drains to intersect them. He could not better illustrate these natural furrows, or channels, than by supposing the artificial ridges and furrows made by the plough in Leicestershire and other clay districts, to be covered to the depth of three or four feet with a surface soil more permeable by water than the subsoil on which it rested. Rain sinking through the soil would collect in the furrow, and if there were any declivity in the channel, it would follow the line of the descent. The Keythorpe drainer cuts his drain across this diagonally, so as to preserve a sufficient fall in the channel. If it were asked how he finds out these channels, he would say that the drainer must dig numerous trial holes to find the point at which water enters, the height to which it rises, and the relative height which it maintains with respect to the holes above it. He then puts a drain in at the greatest distance from his upper hole that he has ever known to free it from water, and if that does not succeed, he puts in another, and sometimes a third. Those were the principles upon which he proceeded. He (Mr. Trimmer) then came to the advantages, which might be summed up in a few words. They were thus enabled to effect the draining of a certain area with fewer drains than by the system of parallel drains at equal distances. A saving of from 30 to 50 per cent. was effected on the cost of drains over intervals of 8 or 10 yards. The Keythorpe drainage had been sufficiently tested on the occasion of the ploughing match on Lord Berners's estate, on the 1st of November last. There had been 48 hours of incessant rain,—indeed, it rained so heavily that it was feared the match would have to be put off. However, it cleared up towards morning, and the match took place in the presence of gentlemen who represented every possible system of drainage, though he was not aware whether a certain Welsh farmer was present, who, when advised to drain his land, said, "it was not intended to be drained, otherwise it would have been made dry by Providence." All those gentlemen were perfectly satisfied with the state of the drainage of the farm on which the match took place. He came now to the objections which had been urged against the system,—the first being that the land could not be sufficiently drained. He would not go into that question, but refer to those who were present here, and had seen it. The next objection was, that if it was drained, the description of the soil, subsoil, and substrata which he had given could not be correct, because it was impossible it could be drained in the manner stated. He had, however, put the facts on record in the *Journal of the Royal Agricultural Society*, and should be happy to meet any objections urged against them in print. The third objection was as to the price,—it being stated that 30s. per acre for the labour of draining land was preposterously low. Lord Berners had a map on which, besides the areas of the fields, were laid down the distance and the depth of the drains, and the amount paid for the labour in draining each field. When he was drawing up the statement as to the cost, he took the average of nearly 400 acres, supplied to him by Lord Berners from the map. Lord Berners had also been examined before a Committee of the House of Lords on the improvement of land, when he put in a portion of this map as evidence, which gave an average for more than 100 acres, closely agreeing with the preceding statements. The result of these collective averages was only a few pence over 30s. Another objection was that there were a certain number of drains only two feet deep; the answer was, that those were made in the old furrows between the old ridges. Immediately the draining was finished these were ploughed down, so that there were now no drains on the farm less than three feet deep.

The CHAIRMAN—There are a few at 18 inches on the map.

Mr. TRIMMER said Lord Berners was present, and would explain the reason of that. It was a mixed system of draining. The next objection was, that professional men could not give their services in such a system of drainage, as they could not be expected to devote their time to probing the soil, to find these subterranean channels; but he (Mr. Trimmer) was satisfied there would be a class of men spring up who would willingly drain land on the cheap system, on the same terms as others drained it on the dear system. The last objection was as to the length of time Lord Berners had been occupied in draining his estate. It was said that it was bad policy to occupy nine years in the draining of an estate, and that it would have been better to have applied to some of the draining companies and borrowed the money, if necessary, in order to drain it out of hand, paying a terminable rent charge in liquidation of the principal and interest. The tenant, not the landlord, it was said, paid for it, and the sooner the work was done the sooner would the landlord be in a position to avail himself of the improvement in an increased rent. That was a question on which landowners must judge for themselves, whether it was better to drain gradually and cheaply with their own money, or to drain at a dearer rate with borrowed money. He had thus gone over all the heads he proposed in the outset. Mr. Denton had told them the extent of land requiring to be drained. They had much of what was called practical draining going on, which was in most cases little better than a burying of pipes—they had much scientific draining which whatever its merits, involved a great burying of money. The Keythorpe system was founded on both science and practice, the generalisations of the former were confirmed by the operations of the latter. It was a system, therefore, well worthy the consideration of landlords who had estates requiring to be drained, and of tenants who it seemed were to pay expensive draining—

it was well worthy the consideration of draining companies, draining engineers, and drainage inspectors; and though last, not least, well worthy the attention of the Inclosure Commissioners, to whom was confided the power of deciding how entailed estates should be drained, if the cost of it was to be charged on the inheritance.

The CHAIRMAN read a list of the depths of the drains on Lord Berners' estate, from which it appeared that they were of the respective depths of 18 inches, 2 feet, 3, 4, and 7 feet.

Mr. HEWITT DAVIS stated, that he had anticipated that the discussion of the evening would have led to a further explanation of the advantages of draining to agriculture, and he had, therefore, prepared himself to have called attention to the advantages to the general health of the surrounding district by a properly conducted system of drainage. He confessed that he expected to have heard more about the principles of draining, and less of the details of particular practice. He had heard the observations of Mr. Bailey Denton with pleasure, but could not say he agreed with him in some of them—for instance, he did not believe there was any economy in shallow draining, for if the depth be diminished, so also must the distance between the drains, and in practice it would be found that the additional quantity of cutting and the extra number of pipes so required, would be more than equivalent to the saving of price in the cutting. Also with regard to the extra closeness of the drains in districts where the fall of rain was greater, he could see a reason for increasing the diameter of the pipes, because they would have more water to discharge; but if the land between the drains were made porous, the quantity of rain that fell could not affect the drains in any other way. With respect to what Mr. Trimmer had said, in his experience he had never found land lying with sub-ridge and furrow to admit of the practice that gentleman had advocated. It must be apparent that to hit these furrows the subsoil must lodge at a regular depth, and the furrows at a regular distance, and that the drains must be cut exactly across the fall, so as to receive the water, and to hold it till its discharge, but where was land to be found in this state? How were the conditions to be discovered, and how were drains to be made to intercept the current? Drain pipes afforded the same facility for water to soak away on the lower side as to enter on the upper, and for this reason would never intercept when placed across the fall. He had prepared a few remarks upon drainage, with respect to the general interest to the public, but as the evening was getting late he would reserve them for another opportunity.

Mr. MECHI considered that we had all seen reason somewhat to modify our views on drainage. It was quite clear that we could not apply one rule to all soils. The hills of Devonshire and Leicestershire, with a frequent out-cropping of springs from silty veins, required a different treatment from the level homogeneous soils of the flat, stiff, clay districts. On a recent visit to Lord Berners, at Keythorpe, near Leicester, he had been much gratified by the complete and economic drainage effected there. His lordship opened a number of deep holes, or graves, in various directions, and thus ascertained the level of the water and direction of the sandy veins intersecting the clay. By carrying a deep drain to one hole, many other distant ones were occasionally laid dry, whilst it sometimes happened that others close at hand required to be immediately connected with the drain. He had, himself, originally commenced with the system of the late Mr. Smith, of Deanston, but had abandoned it for the deeper system of Mr. Josiah Parkes, to whom they were much indebted. Drains could never be too deep in the strongest soils, but we might err in too wide a distance between the drains. He had drained 24, 30, 40, and 50 feet wide, and 5 feet deep, in very strong clays. In all these instances the operation paid, but those drains at the least intervals were the most profitable. Irrigating, as he did, with showers of liquified manure, he had frequently caused the drains (at 5 feet deep in strong clays) to discharge the coloured liquid—and it must be borne in mind that every foot of earth gained and amended in depth, was 1,200 tons of extra soil per acre given to the roots of plants. In his neighbourhood, where a crop of parsnips were growing on the edge of a clay-pit, the roots were observed to descend 13 feet 6 inches—in fact, the whole depth to which this pit had once been filled up.

Lord BERNERS observed, that he felt he owed an apology to the meeting for being so late in his attendance, but as he was obliged to be present at the Smithfield Club Dinner, he hoped that circumstance would be accepted as an excuse. He begged to return his sincere thanks to the Council of the Society for their invitation. He was the last person in the community who would wish to put himself forward, or to enter into any public controversy, but he was always ready to impart any knowledge he might possess on this interesting subject. His system was the result of many years' experience. He had tried, during a period of thirty years, on his farms in Norfolk, Suffolk, and Leicester, the most approved methods of drainage then in vogue, and he had expended several thousand pounds without arriving at any successful result. When it came to be discussed at the Royal Agricultural Society, and when draining assumed more of a science, he took every opportunity of having conversations with gentlemen who were of the greatest note at that time in reference to draining, Mr. Josiah Parkes, Mr. Smith, of Deanston, Mr. Hewitt Davis, who was present, and many gentlemen at the Agricultural Society. It was then laid down by scientific men, that a certain system was best to be adopted, namely, a drain of a certain depth, one saying 3½ feet, another 4 feet, and so on—and that these drains were all to be carried down to the greatest declivity. He stated at a meeting of the Royal Agricultural Society, that he considered it to be presumption for any person to say he could lay down a rule or system of draining for any farm, much less for any district, for in his practice he had found that he could not lay down a system of draining for any single field. It was recommended to him very strongly that he should drain down the greatest declivity in clays such as those he held in his hand. He sent a specimen of the clay to a gentleman who was considered to be the greatest authority in the Royal Agricultural Society at that time, from whom he received a letter stating that it was very true that the quality of the clay he had sent was of a most impracticable character, but that if he persevered there was no doubt that the plan would answer as well as it had answered at Pusey. He accordingly tried the various schemes side by side, though with an impression on his own mind that they would not answer. He watched with anxiety for the result, and found that none of them succeeded. He then cut a diagonal drain across, and freed the whole of that table land. He claimed to himself no merit of originality or novelty, or anything but that judgment which every man could exercise in the case of his own farm, by ascertaining whether the system recommended was applicable to it or not. He did not wish to assume that his plan was the best; but he asked every farmer, and every one interested in draining, to go and see his farm, and he would show them 2,000 acres in Leicestershire, effectually drained, at a cost of £1 or £2 per acre. In Suffolk and Norfolk also, in a ten-acre field, he had more effectually drained it by an additional outlay of £1 to £2 per acre, than by a previous outlay of £10, £15, or £20. He would give them an instance:—He had a very strong retentive clay farm in Norfolk, where he had a very intelligent bailiff, who had been draining under the old system, which he (Lord Berners) did not approve. If he had known then what he knew now, it would have saved him some thousands. He told the bailiff that he was not deep enough, and not draining in the right direction, and he gave him instructions to dig some holes at the end of the field. In about three months afterwards, the man came to him and said that if he would come he would find that the driest part of the field. At the depth of 3½ and 4 feet they came to

little fissures or pipes of sand, like a tobacco pipe, though there was no sand within a mile of the place. Mr. Hewitt Davis had remarked that the under strata ought to be known before they commenced draining, but that there would be some difficulty in carrying out this practice. There would be no difficulty in carrying out the Keythorpe system—any man of common observation would in a moment tell how to do it. He would first speak of grass land. The object of course in all draining was not only to take away the surface water, but to take away what was sometimes called the deep water, or spring water. He held in his hand a sketch which he had made after receiving the invitation from the Council of the Society, and he also felt it his duty to bring samples of the clay, which were there for the inspection of the meeting. In Leicestershire there were ridges and furrows of various widths, from 4 to 11 yards long, and varying in height from 1 to 2 feet, and some 3 feet. He mentioned this, as Mr. Trimmer might, when speaking of ridges and furrows, have alluded to the under strata, while he (Lord Berners) alluded to the upper strata. He had laid down a drain in one field in Leicestershire, and after it had been done seven months, the pipe became filled with a hard substance that prevented the water from flowing.

Mr. MECHI—It entered the drain in solution, I suppose.

Lord BERNERS said, that such must have been the fact. The drain was laid down in a strong stiff clay, near the Conservatory, opposite the drawing-room window, and the result was as he had stated. He had expended several thousands of pounds in trying shallow draining, but his experiments had resulted in failure. In Leicestershire it was said that the proper way to drain was to follow the furrows, but on experience he did not find that system answer. He then tried cross drains, but he was persuaded that the true principle was to take the water from the bottom. If you wanted to empty a cup of water without upsetting it, the proper way would be, not to pierce holes high up in the sides of the vessel, but to make a little hole at once in the bottom, which could not fail to effect the object in view. He had also made experiments with heavy retentive clays, and he had found that if the drains were put as close as they well could be, the water could not percolate. He had tried drains so placed after seven months, eleven months, and two years, and the water had never run out of them. Finding there was no use in draining in that direction, he cut cross-ways wherever he found any porous substance, and then the experiment was successful. In this way he had drained a field of 70 acres, in Norfolk, by a single drain. On one of his farms in Leicestershire, which he had taken into his own occupation at Michaelmas, he found the land so wet and heavy that it could not be crossed by man or horse during the winter, and he found on inspection, that in the intermediate space there were many pounds worth of tiles which the tenant had put into the strong clay, but which were quite worthless; two feet of water standing in the trial holes, below the pan and the upper surface, wet and undrained.

The CHAIRMAN—What was the depth of the tenant's drainage?

Lord BERNERS—From 22 to 26 inches.

Mr. MECHI.—They became what are termed "puddle ponds," did they not?

Lord BERNERS.—If drains were put into this description of clay, the water never could percolate through it. He did not assume to himself any credit for originality in the system of drainage he had carried out, and he would put the sections he had made into the hands of the Chairman, who was perfectly welcome to make what use he pleased of them. There was one point more which he wished to mention, and that was the advisability of keeping a record of the exact places where the drains were put down, and also the situation of the out-falls. In his office an account was kept of each drain, showing its direction, but the small drains were only regarded as adjuncts to the others. If any gentleman present would come to Keythorpe, not for a couple of hours, for that was no use, but for a day or so, he would give him a welcome, and would show him over the land, and he (Lord Berners) believed he would find a triumph of draining not to be met with in any other district. By the use of trial holes they would find not only the proper depth it was necessary to lay the drains in each field, but when those holes were emptied by distant drains, they would see nearer ones were not necessary, and thus the saving of expense effected by the union of porous spots in whatever direction they might occur.

Col. CHALLONER was in hopes that we should have had a little practical information from Mr. Denton, in the course of his paper, upon the method of laying the pipe tiles in drains, because he believed that many of the failures in draining were owing to the imperfect manner in which the pipes were so often laid by the workmen. The great fault was, that they laid in their drains without sufficient attention to the *amount of fall* which they had to dispose of; and very often consumed three-fourths of the fall before they had got half-way to the upper point to which the drain was to be carried. To avoid this, he recommended the use of a common bricklayer's level, with a hinge at one end and a means of fixing it at the other, by which the exact *proportion* of fall might be obtained, and thus the drain be laid in one uniform line from top to bottom. By this means depressions or dips in the drains would be avoided, and the accumulation of sand in the pipes, which was one great cause of failure, would be prevented.

Mr. J. W. BAZALGETTE, the engineer to the Metropolitan Commission of Sewers, stated that he had not come prepared to speak upon the subject, but he should regret to find the discussion resolve itself into an advocacy of either deep or shallow drainage. Undoubtedly the advocates of both systems were to a certain extent right, and it would be impossible to fix upon any depth which could be suitable for all kinds of soil. He (Mr. Bazalgette) agreed with those gentlemen who considered that the natural features of each locality should first be carefully examined, and the drainage works afterwards designed to meet the peculiar requirements of each case. There were a large number of gentlemen present from various parts of the country, each of whom could contribute valuable results, which, when collected, might throw considerable light upon the science of land drainage. It appeared to him that in considering the subject, the first principles to be determined were—First, what is the minimum depth to which the waters should be reduced below the surface, to render the drainage perfect. It might vary considerably in different localities, and for different purposes, and this was a question for the agriculturist to determine. It was then for the land draining engineer to ascertain at what slope the waters would percolate through various soils with sufficient velocity from this minimum depth below the surface towards his drains; and the relative distance between them and the required depth of the drains themselves would then be resolved into a question of comparative cost, and could be determined upon a sure and safe guiding principle. There were still various other most important questions, such as the sizes of pipes, the necessary inclinations for them, and the best mode of laying them, into the consideration of which he would not at that late period of the evening attempt to enter.

Mr. H. S. THOMPSON had no new principle to introduce, and merely rose to offer an explanation of a singular fact, which had frequently been noticed, but, he believed, had never yet been accounted for. It was known that in certain cases deep drains began to run, after rain, sooner than shallow ones, which fact had been long disputed, and when proved beyond a doubt had puzzled the highest authorities in such matters. He had been present at discussions at which Mr. Parkes and others had offered suggestions to account for it, which were not satisfactory to him. He had, therefore, had glass tubes made, of different

lengths, and filled with soil, and had tested the times at which they began to drip when water was poured on them all at the same moment. If the soil was dry, the short tubes, which represented shallow drains, began to run first, but if water was again poured on the tubes before that previously poured on had all passed through, they began to drip again immediately that the second quantity of water was poured on, and without waiting for the water last used to pass through the soil. This was evidently due to the elasticity of the air confined between the free water at the bottom and that at the top of the column of earth, and in this case all the tubes, of whatever length, began to drip at the same moment. If, however, the tubes, after the first application of water, were allowed to remain some weeks, the short tubes discharged the whole of the free water, but the long ones, representing deep-drained land, still retained a little free water at the bottom of the column of earth, and when water was again poured on at the top, this free water was *immediately* discharged, or the deep drain began to run; whereas the short tube, or shallow drain, having discharged all its free water, did not begin to drip for some time,—in fact, not till the water had percolated through the column of soil. He had repeated the experiment in various ways, and always with the same results. This was a small matter, but a fact, however trifling, if rightly explained, sometimes elucidated a great principle, and in this case, by tracing the course of the free water in its passage through long and short columns of soil, he had derived great instruction as to the action of deep and shallow drains, and satisfied himself that there was no fear of making land too dry by deep draining, except in peat soils. The lateness of the hour, however, would not admit of his entering further into the subject on this occasion.

Mr. ROBERT BAKER (of Writtle, Essex) stated that at the late hour at which they had arrived he would not trouble the members with any lengthy discussion; but as Mr. Bailey Denton had made observations upon him in his opening paper, the purport of which he could not clearly understand, he felt called upon not to let them pass entirely unnoticed. He however thought that the discussion was not carried out as put down upon the card, as to the results of draining. The discussion, on the contrary, went to the practical portion of draining, according as each speaker had considered to be most desirable. As for himself, he had little to offer, but he considered that one principle, in a geological point of view, was applicable to every soil—the relieving it of the superabundance of water it might contain; and as the water was held by the porous portion of a subsoil, he did not see the necessity of penetrating the retentive subsoil below to any greater depth than was sufficient to enable the water to collect in the drain below, and thus to be carried to the out-fall and discharged; and then, he submitted, that any fixed depth of four feet or more prescribed for the drains would be totally unnecessary, further than as concerned their durability, and relieving the soil of water to the depth of two feet. It ought to be recollected that, except in cases where the strata had become disrupted suddenly, that the dispositions of the substrata were constantly alternating from a porous to a retentive one, and that in almost every case where a porous strata was found, it would be found resting upon one of an impervious or retentive character, and this invariably occurred, so that throughout the whole disposition of nature, exhibited over large districts, the same law prevailed. Take, for instance, the district upon which his own farms were situated in Essex,—the upper surface strata consisted of beds of gravel sand, loams of every degree of tenacity resting upon the tenacious London clay, which in many instances rose to the surface abruptly. This clay was found resting upon chalk, prevailing at the north-west portion of the county, the chalk also resting upon the tenacious gault clay, that resting upon the green sand, and that, in its turn, resting upon a tenacious clay. Thus the provision of nature was fulfilled of supplying spring-water at every point where these various descriptions of strata approached the surface; and he begged to call the attention of drainers to this particular, as essentially necessary to the development of the science. As regarded what had been stated respecting the Keythorpe estate, he was willing and pleased to corroborate all that Mr. Trimmer and Lord Berners had stated upon it, for when he visited the spot in the early portion of last month, it had been raining almost incessantly for nearly 60 hours previously, and when almost every field had become more or less submerged in water, not a drop was observed stagnating upon the drained portions of his lordship's estate. And to such an extent did this prevail, that in a field upwards of 20 ploughs were in motion for a ploughing-match, without being in the slightest degree incommoded by any superabundance of water; whilst in the adjoining field, that had not been drained, within 100 yards, a draining match was exhibited, and such was the quantity of water discharged by the drains as they became opened, that the drainers were unable to proceed with the work, by reason of the large quantity that followed them during the operation; thus exhibiting by contrast one of the greatest triumphs of draining, and showing how mind had been brought successfully to bear upon matter in an astonishing manner. He would not longer trespass upon them, although he could have desired to have said much more upon the subject. He regretted, however, the diversity of opinion that existed between agriculturists, not only upon this but upon other subjects, for it would be generally found, that if ten of them offered an opinion upon subjects of the most ordinary nature, that all of them would differ.

The Rev. J. C. CLUTTERBUCK wished to say a few words with reference to the observations made by Mr. Trimmer on the peculiar geological condition of the subterranean surface of clays, with reference to which the Keythorpe system of drainage had been carried out. Referring to a section of a ditch cut into the gault clay, the clay rose in waves, or in ridge and furrow, to within about two feet of the surface, the indentations or furrows being filled with drift, and the whole covered with the cultivated soil. Mr. Clutterbuck had observed this condition of subsoil not only in the gault, but in the kimmeridge and Oxford clays, and it no doubt was the same in the lias at Keythorpe. So far as his observation went, these furrows ran at right angles to the dip of the strata, and had no reference to the inclination of the soil, which might or might not be in the same direction as the geological dip of the stratum, but that in a great measure depended on the depth of the drift overlying the substratum of clay. Draining land where this condition of subsoil existed, must depend more on the direction of the drains than on their depth. A drain cut transversely through the subterraneous furrows would drain the land by allowing the water in the drift to escape, whereas drains cut along the line of these furrows would not draw the water which was impounded in the next furrow, though at a distance of only a few feet. A remarkable instance of the effect of cutting through one of these subterranean ridges occurred in making a drain at Oxford, known as the Jericho drain. This drain was cut through the Oxford drift into the Oxford clay beneath; by the section made at the time, it appeared that the drain did not cut across the subterranean ridges up to a certain point, but at that whence it took another direction. Two of these ridges were cut through, and the consequence was, that the wells in that part of Oxford were wholly, or in part, deprived of their water. Had the drain been cut longitudinally to these ridges, the probability was that the effect would not have been the same, and it was mainly to the loss of the water from those wells that might be attributed the successful opposition offered by many of the inhabitants of Oxford to the plan of drainage proposed by Sir W. Cubitt, assisted by Mr. Macdougal Smith. Any one might easily be convinced of the existence of this condition of surface in these clays, and wherever it did exist, no depth of drain

would be efficient except their direction be studied. Trial holes, as described by Lord Berners, or trenches cut in various directions, would enable the drainer to ascertain the existence and directions of these ridges and furrows, and all drainage, to be effective, must have reference to the condition of the subterranean surface of the clay; by this the direction of the drains must be ruled, otherwise large sums might be expended to no effect. This geological condition seemed to be referable to a recent geological period, that was long after the deposition of the strata in which it was found to exist. When the clays were covered with the stratum "in situ," that was, for instance, where the kimmeridge clay was covered with the superincumbent green sand, these ridges were not seen, but where the clay was only covered by drift, then the wave or ridge and furrowed condition was easily traced.

The CHAIRMAN said that, as the hour for adjournment was passed, the discussion must now be brought to a close. At the same time, he hoped that another opportunity would be afforded for resuming the discussion, as it was impossible in so limited a time to do even moderate justice to so important and varied a subject. It would be presumptuous in him to make any remarks on the theme submitted for discussion that night; at the same time he would be glad to offer a few observations, in order to arrange the matter which had been set before the meeting, and to state his own views, as a conclusion of the debate. In discussing a subject of this nature, they must all remember that they were but learners. They could not lay down a rule, but they might lay down a principle; and, he thought, he was justified in saying that a certain principle had been established. It might be considered as established that under-draining a wet soil gave a rapid descent to the water, and secured the dryness of the subsoil. No one, he thought, would deny that although shallow drainage might answer locally, the operation of deep drains had been uniformly successful; and that, although shallow drains were often taken up, there was no instance of deep ones being disturbed. No doubt there were peculiar geological formations that enabled the drainer to accomplish his object at a less expense. His own experience led him to suppose that a drain of from 3 to 4 feet in depth, at intervals of between 6 and 10 yards, came, as nearly as possible within what might be laid down as the best principle. The ancients appeared to have had no defined plans of drainage, as their climate was not so moist as ours, and, therefore, no light was to be gathered from them; but, having seen so many different depths tried, on the whole his own experience was so conflicting that he could not venture to lay down any rule; at the same time he had seen surprising results follow from the difference in depth between 3 and 4 feet. He thought that the Keythorpe system was one in which the science of geology was made to assist the labours of the drainer, and that a great reduction of expense was effected by its application.

Lord BERNERS said, with respect to depth, one of the great advantages of trial-holes was, that the proper depth could be ascertained. First of all you must dig to such a depth as that the water will come in freely; a little deeper, then, to see whether the water would accumulate fast, and by that means, if you come to anything like a porous soil, it was deep enough.

Mr. ACLAND stated, as one more fact bearing on the question of the direction of drains, that in Devonshire it was found to be of great importance to lay the drains across the lines of stratification, which generally run from east to west.

The CHAIRMAN trusted the subject would be taken up on another evening, and that as many would attend as possibly could. Although the subject of draining had been really, in some sense, exhausted, still the local peculiarities had to be attended to, and the question would bear much further discussion.

A vote of thanks was then unanimously passed to Mr. Denton for his paper.

Mr. DENTON thanked the meeting for the vote the Chairman had just communicated to him, and said that as he did not wish them to separate with an impression that he was an advocate of one universal system of draining for all soils, and under all circumstances, he must take that opportunity of repeating, that he only acknowledged *one* fixed rule, and that was the *principle of depth*.

The Secretary announced that the Paper to be read at the meeting of Wednesday next, the 19th instant, was "The Present Position of the Iron Industry of Great Britain, with reference to that of other Countries," by Mr. J. Kenyon Blackwell. On this evening Mr. Joseph Glynn, F.R.S., will preside.

*** It having been represented that there were still many gentlemen who were anxious to offer some remarks on the "Under-drainage of Land in Great Britain," the Secretary is authorized to state that an Extra-Ordinary Meeting has been fixed for *Friday*, the 21st inst., at 8 p.m. precisely, for the purpose of renewing the Discussion.

PARIS EXHIBITION, 1855.

THE PAPER MANUFACTURE.

Some of our members who have visited Paris during the past summer, having adopted the commendable course of giving their opinions through the medium of the *Journal*, upon subjects with which they are familiar, in following their example I venture to hope that a short memorandum on the Paper Manufacture, as it appeared in the Exhibition, may be acceptable to some of your readers.

MACHINES.—The most noticeable articles of this class were:—

1. The rag-engine, cast in one piece, and having a smal steam-engine attached. (M. Gratiot, Class 6, Sec. 10.)

For mills where paper is made from straw, and requiring but little steam-power, this combination, for compactness and economy, presents some points worthy of consideration. The motive power being close to the work to be done, no loss is incurred by gearing, and, although not adapted for all cases, might be advantageously employed in certain circumstances.

2. A pulp meter, on a simple principle. (Prussia, 252.) The machine appeared to be perfectly under the control of the workman, and large and small differences in the quantity of material used could be easily gauged.

3. Cutting machine for paper and millboards. (Paris, Poirier, Porte St. Martin.) Possesses great power and rapidity of action. The cut is diagonal, and by the judicious combination of a system of double levers and an eccentric, the table and knife both move, thus facilitating the operation; and no reverse motion is necessary to separate the knife from the table carrying the paper. Moreover the table and knife alternately close and separate, in whichever direction the handle may be turned.

MATERIALS.—Of these I noted the paper exhibited by:—1. Messrs. Coupier and Mellier (France, 2889), composed of 85 parts straw and 15 parts paper shavings.

The price at which dry pulp could be produced was stated to be 50f. the 100 kilogrammes, or about £1 per cwt. If the prospect thus held out can be realised to the extent of one-half, it offers great consolation to those who have been fearing the failure of paper materials.

2. The specimens of paper shown by Messrs. Louvié and Yelli, made of the *Mussa paradisaica* were very interesting, but the cost of production was not stated.

3. Some specimens of a new material, the name of which was not however given, exhibited by the Papeterie de Majoulassy, were remarkable chiefly for the apologetic manner in which they were submitted for inspection. I subjoin a translation of the peculiarly French announcement which accompanied them :—

"I am a new product, still in my infancy;
If I am not white, it is not that I come from Africa,
For I am French; I might be Spanish,
German, English, in fine wherever agriculture flourishes.
Who cultivates me will not lose his time;
Then I shall become a great source for the making of paper.
Without wishing to dethrone rags, I may be worthily their succedaneum.

P.S.—If I dare to present myself such as I am, it is that the Exposition is too soon, or that I have been discovered too late; there has not been time to make my toilet; all my substance is capable of being whitened."

Of ultramarine many specimens were exhibited, but as the quality of this article can only be properly tested in the working, it would be unfair to give an opinion. I only noticed one maker who affixed his price (Rohr, of Wiesbaden), from which it appeared that his best quality was deliverable on the banks of the Rhine at 100fr. the 50 kilos., or 8d. per lb., about half the price the best quality is sold for in this country.

PROCESSES AND RESULTS.—Several novelties were well deserving the attention of manufacturers.

1. Undoubtedly the most important exhibition in the whole of this Class was that of Messrs. Pirie and Sons, of Aberdeen, consisting of cartridges, bags, and bottle wrappers, made in one piece, by the paper machine out of pulp, without join or seam.

So important has this invention been deemed by the English Government, that special works are now in process of erection at Woolwich, for the manufacture of cartridges on this principle.

2. Messrs. Drewsen (Danish Monarchy, 35) exhibited some excellent specimens of papers *satined* in the web; and from the different surfaces of the papers the degree of glazing seems perfectly under control.

3. Mr. T. H. Saunders, of London, likewise exhibited some satined webs, and in addition to reams of paper of his own manufacture, his stand presented a collection of specimens, forming a complete epitome of the English paper manufacture, from bank-note and ornamental paper to the coarsest brown and packing papers, divided into five classes :—

1. Papers made by hand.
2. Papers made by machinery.
3. Special papers, including bank-note, parchment, loan, watermarked, and coloured papers.
4. Papers forming the raw materials of other manufactures, or requiring some further operation before use by consumers.
5. Packing and wrapping papers.

The specimens were bound in volumes, with suitable descriptive letter-press.

4. M. Firmin Didot's improvement in the mode of bleaching, of which a diagram of plans was exhibited, consists in the application of carbonic acid to facilitate the separation of chlorine from lime. Whether the bleaching material be applied in the engine or a chest, the carbonic acid is conducted into the apparatus, and, combining with the lime, releases the chlorine. From those who have witnessed experiments, it is understood that a considerable saving of time is effected by this process.

5. M. Gary (France, 2882) exhibited some excellent cigarette paper.

6. Hoesch and Fils, of Düren (Prussia, 409), exhibited a very good collection of coloured papers.

7. The Essones Company state that they make four tons of paper per day, and two million envelopes a month. They have four machines, and employ 350 workmen, for whom they provide lodging, garden, saloons, medicine, school, and hospital;—a very good example to our large English manufacturers.

Several other manufacturers exhibited, but as their articles were either inclosed and therefore inaccessible, or of trifling importance, I pass them over. I may, however, just allude to a bag-making machine, and a numbering apparatus of simple construction, both from the United States. I did not observe one of the elegant though rather complex numbering machines used in this country.

An ingenious contrivance for marking the level of liquids, and applicable in several branches of this manufacture in common with others, consisted in the use of a magnet floated in the interior of the vessel, and a small needle of iron outside. As the magnet rose or fell by the increase or diminution of the liquid, the height was indicated on the exterior by the small needle.

I may observe that although the Jury awards have been made since the preceding notes were penned, I do not find in those awards any reason to alter the opinions formed in the building itself; in fact, my view of the subject of awards, and the whole system of juries, founded upon the results of the Exhibition of 1851, has been more than confirmed by the working of the present Exposition.

It is almost impossible to obtain a competent and fair jury, for if the judges know nothing of the specialities of the articles submitted, it is unreasonable to suppose that the relative merits can be duly estimated; and if they are conversant with the points of eminence which each manufacture should aspire to possess, they have for the most part been connected with the manufacture, and it would be demanding of them to discard some portion of the constitution of their nature, to require that they should retain neither prejudice nor prepossession.

In addition to this serious difficulty, another presents itself, the working of which it is amusing to those not interested to observe. I refer to the circumstance that exhibitors have to pass through a second ordeal, in which the verdicts of the juries are ruthlessly set aside, frequently without their being consulted, sometimes even against their protest.

As one instance, your readers will recollect the great musical squabble between Messrs. Erard, Broadwood, and Collard, who, in 1851 were each recommended by the jury for the Council Medal; the judgment of the jury, selected for its competency, was set aside by gentlemen who never professed to understand the manufacture of musical instruments, and the Medal awarded to one firm, to the prejudice of the other two. Injustice brings its reward, the injury of 1851 caused the absence in 1855 of the productions of two establishments whose articles would have reflected honour on the country.

In this respect we cannot say they manage matters better in France, for Prince Napoleon states in the report to the Emperor, that *after* the majority of the jury had left Paris, the Council of Presidents took upon itself to reduce into the Silver Medal Class 200 *eminent manufacturers* who had been recommended for the gold medal.

The injustice of this proceeding cannot be sufficiently condemned, bringing juries and awards into disrepute, and leading one to hope that, should a Universal Exhibition be ever attempted again in this country or anywhere else, the whole system will be utterly rejected.

W. STONES.

Home Correspondence.

MR. F. WEBSTER ON THE ORATORY OF THE SENATE.

SIR,—If the Institutions in Union were generally to send you information respecting the incompetency of certain lecturers, much disappointment and vexation might be saved; and I feel it to be a matter of duty, as a warning to other Institutions, to make public at once, facts relative

to a lecture just delivered here by Mr. F. Webster, of Weymouth-street. The committee of the Croydon Literary Institution, believing that the lecture on the "Oratory of the Senate," which Mr. Webster offers to deliver at Institutions, would be useful and acceptable to their members, engaged him for last night. He made his appearance accordingly, but his lecture gave general dissatisfaction, for an *extempore* and able address was expected from a professional elocutionist. At the commencement of the lecture, allusion was made to the mouth and organs of speech, when, to the surprise of all present, Mr. Webster intimated that he would pause a few moments, to introduce a friend of his, whom he alluded to as the son of Mr. So-and-so, of such-and-such a number and street (giving the full address with all distinctness), the *celebrated dentist*, who had invented and *patented* wonderful improvements in the construction of false palates, &c. The individual alluded to then stepped up on the platform, and commenced reading from the manuscript at the point where Mr. Webster had left off. He held in his hand a model, with a set of artificial teeth and palate, and explained the unrivalled manner in which such appliances were constructed at his establishment. I need hardly add that this exhibition offended all present. Upon being remonstrated with after the lecture, Mr. Webster endeavoured to make it appear that his friend explained matters which he himself was unacquainted with; but the attempted explanation is perfectly absurd, as the *whole thing was written from beginning to end*, and surely the dentist's part might have been *read* by Mr. Webster. The person who obtruded himself on the audience in so unseemly a manner is connected with a regular advertising concern in London. Trusting this *exposé* will save many an Institution the annoyance of being employed as a vehicle for puffing,

I remain, Sir,

Your most obedient servant,

SAMUEL LEE RYMER,
Honorary Secretary.

Croydon, Literary and Scientific Institution, Nov. 27th, 1855.

MR. HARRY SCRIVENOR'S PAPER ON THE IRON TRADE, AND THE DISCUSSION THEREON.

SIR,—As Mr. Harry Scrivenor refers in his valuable paper read last Session, to the account in his own volume of the astonishing results effected on the growth and the expansion of our iron trade, by Mr. Cort's inventions of puddling with the flame of coal, and subsequent conversion of the copious produce into bars by his grooved rollers, I perhaps ought not to complain that he considered it out of place to notice at more length the merits of a man who has truly been to Great Britain, what is designated in the words of Locke *the Father of Arts and author of plenty*. Previous to the invention of grooved rollers, rolling had only been applied to the manufacture of sheet iron, for tin plates, &c., and all small sizes of bars were obtained from larger hammered bars, subjected to the *slitting mill*, invented in Sweden, and which the indomitable ancestor of the present Lord Foley imported from that country, about the year 1740, by a series of adventures which form a great practical romance, and earned a fortune and a peerage. The very different reward which Cort received for his much greater services is certainly a painful reminiscence, and, therefore, probably out of place amidst the calculations of prosperity. But I beg to be permitted to offer a few words on Mr. Bird's remarks in reply to Mr. Scrivenor. I cannot say I fall into this gentleman's peculiar train of reasoning upon the fluctuations of the iron trade. Thus he attributes the rise in the price of iron which occured one year after the Great Exhibition in 1851, and five years after the panic depression of 1847, to the display, on that occasion, of our raw material, which induced foreigners to come and buy the iron which they perceived it could furnish. I cannot at all agree that these facts stand in the relation of cause and effect. The fluctuations of the iron trade have been constant at more or less regular intervals, and have been produced by far more important events than Mr. Bird appears to suppose. There were no foreign visits in 1845 to raise the price of bars from £4 10s. to £12 per ton. He is equally at fault in attributing the era of the existence of *cheap iron* to the invention of the hot blast. Hot blast was in full use in 1845-6-7, when iron ranged at £10 to £12 per ton, and he will find by reference, that at intervals, long prior to the use of the hot blast, iron was cheaper than it is now. The era of *cheap* iron dates as far back as the year 1785, when for the *first time* British iron was *made* of a quality fit for anchors and other first-rate uses, *tried* successfully at the Royal Dockyards, and reported on by that celebrated light of science, Dr. Black. This is the date of the era of *cheap* British iron at £10 per ton, substituting *Russian iron* at £35. That Mr. Bird may not remain under a mistake in so very important a matter, I beg to refer him to a cotemporary authority, too conclusive to be overlooked, who witnessed the progress of this amazing change, the Earl of Sheffield, who wrote the following passage in 1786:—"If Mr. Cort's very ingenious and meritorious improvements in making and working iron, and *his invention of rolling bar iron*, and the great improvements of the steam-engine by Watt and Boulton should all succeed, the expense may be reduced so greatly that British iron may be afforded *as cheap* as foreign, even if the latter should be allowed to enter duty free, *perhaps cheaper* and of as improved a quality, and in quantity equal to the demand, then it is not asserting too much to say that that event would be more advantageous to Great Britain than thirteen colonies; it would give the *complete command of the iron trade to this country*, with all its vast advantages to navigation."—*Observations on the Commerce of the United States*.

These remarks are prophetic, and they have been fully realised. I think no person conversant with our metallic industry should remain a moment in ignorance of so great a land-mark in its history.

I am, Sir,

Your obedient servant,

DAVID MUSHET.

December 10th, 1855.

Proceedings of Institutions.

ALTON.—The eighteenth annual report of the Mechanics' Institution states that a reading-room, which has lately been opened for day readers, has been much frequented. There are about 50 members, who pay an annual subscription of one guinea each, in order to avail themselves of the use of this room, which is open from 10 A.M. until 10 P.M. The quarterly subscribers, and those who pay annually less than a guinea, are admitted at 5 o'clock, instead of 7, as formerly. The lectures during the last winter were 11 in number, and were delivered by Mrs. Balfour, and Messrs. Macintosh, Wheeler, Grossmith, Moody, Ryde, Williams, Hughes and Ellis Roberts. It was announced that the Museum will be opened early in the ensuing year. The number of members is 89 annual and 114 quarterly; of the latter by far the larger proportion are mechanics, apprentices, and boys. The receipts during the year amounted to £108 0s. 5d.; the expenditure to £106 12s. 6d., but as there was a sum of £15 14s. 3d. due to the treasurer at the end of the previous year, there is still a deficit of £14 6s. 4d.

EPSOM AND EWELL.—The fourth annual report of the Literary and Scientific Institution congratulates the members on the continued support it receives. Of the existing members thirty-nine pay £1 1s., and twenty-one pay

10s. yearly; forty pay 2s. 6d., and eleven pay 1s. 6d. quarterly. The total revenue from subscriptions and donations during the past year amounted to £81 7s. The library has received considerable additions, but the Committee have refrained from expending the whole of the available resources, believing that they might be found valuable at a possible future period of depression. The balance in the hands of the Treasurer amounted at the close of the year to £71 6s. 9d. The number of issues was 658 volumes. Of these 162 were works of fiction; 130, general literature; 70, biography; 110, periodicals; 45, reviews; 45, books of travel; 18, history; and 18, poetry and the drama. During the year two concerts were given by the English Vocal Union, to which a small charge was made, and six lectures were delivered.

HACKNEY.—On Wednesday evening, November 29th, Mr. John Bennett, F.R.A.S., delivered an interesting lecture at the Literary and Scientific Institution, on "The Birth, Parentage, and Education of a Watch." The origin and history of watches were noticed with the progressive stages of improvements. The different parts of a watch were dwelt on and explained and exemplified by a great variety of specimens. The compensation-balance and pendulum clearly explained, and most interesting details given with respect to the manufacture of watches in Great Britain and Switzerland, showing that there was a greater subdivision of the work in the latter work, so that each individual was employed upon that part in which he or she might excel. The lecture was listened to with great attention, and was both interesting and instructive.

STALYBRIDGE.—On the 19th inst., J. D. P. Astley, Esq. (lord of the Manor of Dukenfield), who has lately returned from the Crimea, delivered a lecture at the Town Hall, to the members and friends of the Mechanics' Institution, "On the Siege of Sebastopol," in which he described, in a familiar manner, the operations of the siege, offensive and defensive, from the commencement, in 1854, to the fall of Sebastopol.

TENTERDEN.—A lecture, in connexion with the Mutual Improvement Society, was delivered in the Town-hall, on Wednesday evening, Nov. 21st, by the Rev. H. Solly, on "The Nature and Character of a Gentleman, Historically, Conventionally, and Rationally." The opinions of every grade in every phase of society on the subject were given, from the aristocracy to the apprentice boy. The influence exercised on society by the Christian gentleman was justly described, and the lecturer urged upon all in every rank and grade the necessity and importance of being Christian gentlemen, the essential elements of which consist in self-respect and respect for others.

WINCHESTER.—The Hants and Wilts Adult Education Society intend offering to all places having Institutions in union a gratuity of two pounds, in money or books, to the teacher who shall have conducted an evening class or classes during the current session, ending April 30th, 1856, to the satisfaction of such inspector or inspectors as they may appoint, subject to the following conditions and limitations:—

1. That the gratuity thus offered be doubled from local sources independent of the payments made by the persons attending the classes.
2. That no pupil be under the age of 15 years.
3. That the average number of the class shall not be less than two per cent. of the population of the town or village, nor in any case less than seven in number.
4. That the aggregate attendances of each person under instruction shall not be under 50, of two hours each, to be certified to the satisfaction of the inspector.
5. That reading, writing, and arithmetic be deemed essential subjects of instruction; but that geography, English history, and other branches of knowledge, will be favourably considered and reported on by the inspectors.
6. That the progress and condition of the classes meet the approbation of the inspector. The committee reserve to itself the power of withholding the gratuity on the ground of insufficient merit, or of marking its sense of higher efficiency by increasing it.

Another proposition issued by the committee relates to the union of libraries and interchange of books, viz:—

1. The libraries of a district shall be grouped together, as may be considered most convenient by the local secretary, and with the consent of the libraries formed into an union.
2. Boxes shall be provided for the transfer of books by each library.
3. Catalogues of each library shall be interchanged with the libraries of the union.
4. Every member of any of the libraries shall be entitled to the use of any book in any of the other libraries (except such as are not allowed to be taken out of the room), on giving in the name of the book to the librarian of his own library, on or before the 25th of each month. No one shall be entitled to apply who has not returned any books he has before received.
5. Each librarian shall collect and return, on or before the 27th of each month, the books received the preceding month, and forward a fresh list of those applied for. The carriage shall be paid by the librarian receiving the books.
6. No book shall be sent out that has not been six months in the library.
7. No library shall apply for more than one volume for every ten volumes of its own library. Volumes not returned shall be counted as against the library applying, and a forfeit of 1d. per week shall be paid by the person detaining a volume over two months, and remitted by his librarian to the library to which the book belongs.

MEETINGS FOR THE ENSUING WEEK.

MON. London Inst., 7, Mr. Charles Cowden Clarke, "On the Genius and Comedies of Molière."
Architects, 8, Mr. Edward I'Anson, "On some French Chateaux of the Age of Francis the First."
Chemical, 8.
Statistical, 8, Dr. W. A. Guy, "On the Nature and Extent of the Benefits Conferred by Hospitals on the Working Classes and the Poor."

TUES. Civil Engineers, 8, Annual General Meeting.
Linnæan, 8.
Pathological, 8.

WED. Society of Arts, 8, Mr. J. Kenyon Blackwell, "The Present Position of the Iron Industry of Great Britain, with Reference to that of other Countries."
Geological, 8, 1. Mr. P. J. Martin, "On some of the Geological Features of the Country between the South Downs and the Sea." 2. Prof. Owen, "On the Remains of the Musk Ox (Bubalus Moschatus) from the Gravel, near Maidenhead, Berkshire."

THURS. Antiquaries, 8.
Royal, 8½.

FRI. Philological, 8.
Society of Arts, 8, *Extra-Ordinary.* Renewed Discussion on Mr. Bailey Denton's Paper, "On the Under-Drainage of Land in Great Britain."

SAT. London Inst., 3, Mr. T. A. Malone, "On the Elementary Principles of Vegetable and Animal Chemistry."
Medical, 8.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette December 7th*, 1855.]

Dated 28th July, 1855.

1715. Charles Emile Paris, Paris—A new material to be used in the manufacture of crystal, enamel, and other similar products.

Dated 12th October, 1855.

2279. John Clark, Strand—Cooking apparatus for the pocket.

Dated 22nd October, 1855.

2361. Charles Lenny, Croydon—Improvements in carriages.

Dated 27th October, 1855.

2397. Edward Stark, Monkton, Isle of Thanet—Improvements in pens for writing.

Dated 1st November, 1855.

2433. James Leetch, Margaret-street—Improved method of constructing apparatus for the covering of the head.

Dated 20th November, 1855.

2610. John Poole, 2, Ryley-street, Chelsea—Improved mode of regulating the supply of steam from the boiler to the cylinder,

and thereby better governing the motion or speed of steam-engines.

2612. Alfred Vincent Newton, 66, Chancery-lane—Improved apparatus for dressing flour. (A communication.)

2614. William Harvey, Mansfield—An apparatus to be employed with reals, cylinders, or rollers, and for placing upon or taking off therefrom hanks, skeins, bands, and other articles without removing such reels, cylinders, or rollers from their bearings.

2616. Charles Frederick Clark, Wolverhampton—Improvements in bolts and fastenings, which they propose calling Clark and Co's Longitudinal Wedge Bolt.

2618. David Simpson Price, 2, South Molton-street, and Edward Chambers Nicholson, 3, Newington-crescent—Improvements in the manufacture of cast iron.

2620. Oliver Maggs, Bourton Foundry, Dorset—Improvements in machinery for thrashing and winnowing wheat and other grain.

2622. Coleman Defries, Houndsditch—Improvements in the roof lamps for railway carriages.

Dated 21st November, 1855.

2626. Peter Armand le Comte de Fontaine Moreau, 4, South-street, Finsbury—Improvements in treating fatty acids. (A communication.)

2628. Henry William Wimshurst, St. John's-wood—Improved machinery for cutting dovetails and tenons.

Dated 22nd November, 1855.

2630. Alexander Tolhausen, 7, Duke-street, Adelphi—Improvements in bombs and other explosive projectiles whose charges are to be fired by percussion. (A communication.)

2632. George Price, Cleveland Safe Works, Wolverhampton—A box, chest, or case, for the preservation of parchment deeds and documents from damage by steam, when placed inside an iron safe made fireproof on the vapourising principle.

2634. Henry Hibling, Norwich—Improvements in waterproof boots and shoes.

2638. John Henry Johnson, 47, Lincoln's-inn-fields—Improvements in apparatus for making aerated beverages. (A communication.)

Dated 23rd November, 1855.

2640. Thomas Tuckey, Cork—Modes of construction, by which steam or other vapour or gas may be used as a source of motive power for some purposes more conveniently than hitherto, and more suitably for locomotion on common roads.

2642. John Pursloe Fisher, Edgbaston, near Birmingham—Improvements in the construction of the hammers of pianofortes.

2644. Joseph Ellisdon, Liverpool—Improvements in 'castors' for cabinet-furniture.

2646. Samuel Cunliffe Lister, Bradford, and James Warburton, Addingham—Improvements in spinning.

Dated 24th November, 1855.

2648. Samuel Ratcliffe Carrington, Stockport—Improvements in the manufacture of hats.

2650. John Jephson Rowley, Rowthorn, near Chesterfield—Improvements in machinery for cleaning and cutting turnips and other roots.

2652. Juliana Martin, Soho-square—Improved self-acting incubator.

2654. Hiram Hyde, Truro, Nova Scotia—Improvements in the manufacture of mineral oils. (A communication.)

Dated 26th November, 1855.

2658. Enoch Harrison and Hilton Greaves, Manchester—Improvements in the manufacture of woven fabrics.

2660. Thomas Greenwood, Leeds—Improvement in the construction of carding engines.

2662. George Edward Dering, Lockleys, Hertford—Improvements in galvanic batteries.

2664. James Clark, 25, Billiter-street—Improvements in the chain wheels used on capstans, windlasses, and other axes.

Dated 27th November, 1855.

2666. Thomas Allan, Adelphi-terrace—Improvements in applying electricity.

2668. Hiram Hyde, Truro, Nova Scotia—Improved manufacture of lubricating compound. (A communication.)

2670. Enoch Tayler, 62, Baldwin's-gardens, Gray's-inn-lane—Improvements in paddle wheels for propelling vessels in water.

2674. Samuel Amos Kirby, Hastings-street, Leicester—Improvements in open stoves and grates for rooms and apartments.

2676. John Henry Johnson, 47, Lincoln's-inn-fields—Improvements in sheathing ships. (A communication.)

2678. John Henry Johnson, 47, Lincoln's-inn-fields—Improvements in cleaning and hulling grain and seeds, and in the machinery or apparatus employed therein. (A communication.)

2680. Thomas Warren, Glasgow—Improvements in the manufacture and moulding or shaping of glass.

Dated 28th November, 1855.

2682. Charles Herbert Holt, Manchester—Improvements in steam boilers, furnaces for the same, and apparatus connected therewith.

2684. George Richardson, Craig's-court, Charing-cross—Improvements in buffer, draw, and bearing springs for railway carriages and waggons. (A communication.)

2686. Joseph Lee, Stonall, near Walsall—Improvements in agricultural or farmers' engines, which improvements are applicable also to locomotive engines.

2688. William Alfred Distin, 31, Cranbourn-street, Leicester-square—Improvements in cornets and other wind musical instruments.

WEEKLY LIST OF PATENTS SEALED.

Sealed December 5th, 1855.

1279. John Gedge.
1289. John Gedge.
1294. James Robertson.
1295. Henry Nunn.

Sealed December 7th, 1855.

1313. George Frederick Chantrell.
1325. William Kemble Hall.
1342. Charles Parker.
1345. Frederick Collier Bakewell.
1346. Frederick Collier Bakewell.
1347. John Avery.
1353. Joseph Betteley.
1397. Francis Burke.
1401. John Henry Johnson.
1415. Louis Pol.
1419. Wiliam Crane Wilkins.
1426. William Basébé.
1430. Auguste Edouard Loradoux Bellford.
1435. Auguste Edouard Loradoux Bellford.
1437. Auguste Edouard Loradoux Bellford.
1439. Capt. Herbert Newton Penrice, R.E.
1446. Auguste Edouard Loradoux Bellford.
1448. John Young.
1454. Auguste Edouard Loradoux Bellford.
1456. Frederick Leiss and Charles Schneider.
1465. Henry John Distin.
1476. Carl Christian Engstrom.
1528. Alexander White.
1577. Robert Yeates.
1587. Francis Burke.
1630. Edward Augustus Ferryman.
1796. Robert Barlow Cooley.
2011. John Hamilton Glassford.
2064. John Guy Proger.
2109. Alfred Vincent Newton.
2200. François Fortuné Benvenuti.
2264. William Edward Newton.
2271. Jane Ann Herbert.

Sealed December 11th, 1855.

1328. John David Kind.
1340. William Beckett Johnson.
1350. William Moxon and John Clayton.
1352. Joseph Betteley.
1359. Joseph Enouy.
1364. William Hewitt.
1367. Henry Bridgewater.
1372. Dumont Pallier.
1373. William Jones.
1428. Luther Young.
1458. Moses Poole.
1502. Richard Tidmarsh.
1519. William Richard Morris and William Morris, and Richard Chrimes and George Eskholme.
1811. William Henry Lancaster and James Smith.
2030. Henry Hart.
2046. Charles Hewett.
2058. Joseph Camp Griffith Kennedy.
2254. James Murdoch.

PATENTS ON WHICH THE THIRD YEAR'S STAMP DUTY HAS BEEN PAID.

December 3rd.

960. Joseph Bentley.
967. Richard Archibald Brooman.
1139. John Livesey.

December 5th.

974. Edward Tucker.

December 7th.

998. Donald Beatson and Thomas Hill.
1048. James Bell.

WEEKLY LIST OF DESIGNS FOR ARTICLES OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietors' Name.	Address.
3792	December 6.	The Crochet Cotton Armlet	George Grout	Tottenham.
3793	,,	Pair of Trowsers	Richard Day Charles	Bristol.
3794	10	A Steamer for Potatoes	Daniel Wm. & Thos. Bentley	Margate.